ISSN 0377-9335

entomon

A Quarterly Journal of Entomological Research

Vol. 6 DECEMBER 1981 No. 4

PUBLISHED BY
THE ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY
DEPARTMENT OF ZOOLOGY, UNIVERSITY OF KERALA, KARIAVATTOM
TRIVANDRUM, INDIA 695 581

ENTOMON

Entomon is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other land arthropods excluding gross anatomy, histology and morphology.

Address MS and all editorial correspondence to the Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695 581.

SUBSCRIPTION RATES

Annual subscription for institutions: Rs. 80/- (in India); U. S. $ 30/- (abroad)
„ individuals: Rs. 50/- „ ; U. S. $ 20/- „

Address all business correspondence to the Secretary-Treasurer of the Association.

---

1. **All remittances to the journal or the Association should be sent to the Secretary-Treasurer of the Association.**
2. **Cheques should be A/c payee in favour of the Association for Advancement of Entomology.**
3. **Requests for replacement copies of ENTOMON in lieu of numbers lost in transit, should reach the Secretary-Treasurer not later than three months (nine months for requests from abroad) after the date of issue of the number.**

entomon

Volume 6 December 1981 Number 4

CONTENTS

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 287 *to* 296

SEX CHROMATIN ELIMINATION IN THE POLYMORPHIC MALE PYRRHOCORID BUG, *IPHITA LIMBATA*

G. K. MANNA[1] & S. DEB-MALLICK

Department of Zoology, University of Kalyani, Kalyani 741 235, West Bengal, India

(Received 14 June 1981)

Males of *Iphita limbata* reported by others to have $2n = 20$ ($12+2m+6XO$) and $2n = 23$ ($22 + XO$) while we found $2n = 16$ ($12 + 2m + XX$) in oogonial plates and $2n = 23$ ($12+2m+9XO$) chromosomes in spermatogonial plates. In males one *X*, slight-differential, was the original while 8 others were product of it and they formed variable associations during spermatogenesis. Typically metaphase I contained centrally situated *m*-pair, 6 autosomal bivalents around it and 9 *X* elements formed various dispositions. Anaphase I was equational for *X* elements as metaphase II contained 6 autosomes, 1 *m* and 9 *X* elements mostly in two groups of 4 and 5. Anaphase II was reductional for the sex elements when 5 and 4 *X* elements moved to opposite poles with 6 autosomes and 1 *m*-chromosome. Four *X* elements in each pole showed sign of degeneration making only the original *X* viable. Thus it was suggested that in male embryo during early cleavage, the single original *X* gave rise to 8 extra *X* elements by a suspected mechanism of gene amplification. These extra 8 *X* elements were eliminated after anaphase II and would originate again from the original *X* in males of the next generation. Male individuals of the present population were chromosomally polymorphic as compared to other two populations studied by others.

(*Key words:*—origin and elimination of extra *X*, male bug, *Iphita limbata*)

INTRODUCTION

The largid bug, *Iphita limbata* appeared cytologically polymorphic since different workers including the present authors had found different diploid numbers and sex chromosome constitutions in males of this species. BANERJEE (1958) described $2n = 20$ chromosomes in the spermatogonial metaphases which at metaphase I comprised six autosomal bivalents, a pair of *m*-chromosomes and six *X* chromosomes; the latter remained fused in other stages. The account given by BANERJEE (1958) was rather incomplete as he did not determine the oogonial number in claiming the six *X* chromosomes and no *Y* in male. However, later RAJASEKHARASETTY (1963) reported in males of the same species, collected from a distance of about 2,600km the occurrence of spermatogonial number of 23 chromosomes which comprised 11 pairs of autosomes and only a single conspicuously large *X* and there was no *m*-chromosome pair. The meiosis was of orthodox type as found in *XO* males of other heteropteran species (MANNA, 1951). Very likely RAJASEKHARASETTY (1963) missed the paper by BANERJEE (1958) on *I. limbata* as no comparison was made by him between the two findings. These findings

Grateful acknowledgement is made to the University Grants Commission, New Delhi for the financial support.

were fundamentally different with regard to diploid number, sex chromosome constitution etc.

During the survey of chromosome numbers and their behaviour in males of different species of Heteroptera carrried out by us (MANNA, 1951, 1957, 1958, 1962; MANNA & DEB-MALLICK, 1980, unpublished), we came across a population of *I. limbata* under present report which showed the peculiar phenomenon of the origin and elimination of extra *X* chromosomes during spermatogenesis not reported by earlier workers. The elimination of chromosomes of various nature though reported in *Ascaris*, other group of insects and man *(vide infra)* cited by WHITE (1973), the phenonmenon under present report has been somewhat peculiar and not exactly was known in Heteroptera.

MATERIAL AND METHOD

Sixty adult males and twelve females of *Iphita limbata* (Pyrrhocoridae : Heteroptera) were collected from the host plant, *Trewia nudiflora* at Kalyani, a place also located in West Bengal separated by a distance of about 50 km from that of BANERJEE (1958) and by 2,600km from that of RAJASEKHARASETTY (1963) viz., Trivandrum, Kerala. Testes of each male were fixed in acetic-alcohol (1:3), separately squashed and stained normally with iron-alum haematoxylin and in some cases with Feulgen stain. Similarly, ovaries of each female were fixed, squashed and stained to determine mainly the oogonial number; but only 5 out of 12 individuals tried yielded some divisional stages suitable for chromosome studies.

OBSERVATIONS

In the ovary, the diploid number of 16 chromosomes determined from 30 plates in prometaphase and metaphase stages (Figs. 1, 21) consisted of *m*-chromosomes demarcated by their minute size and differential stainability and 14 other chromosomes showing no such distinguishable features among themselves. The latter ones included a pair of *X* chromosomes which was predicted only after studying meiosis in males *(vide infra)*. In early primary oocyte prophase nuclei, two positively heteropycnotic bodies of similar size could occasionally be seen among other diffusedly stained autosomal bivalents (Fig. 2). They possibly represented the two sex chromosomes which more often fused to form a single large mass. The behaviour of the two *X* chromosomes could not be followed further for lack of other oocyte stages.

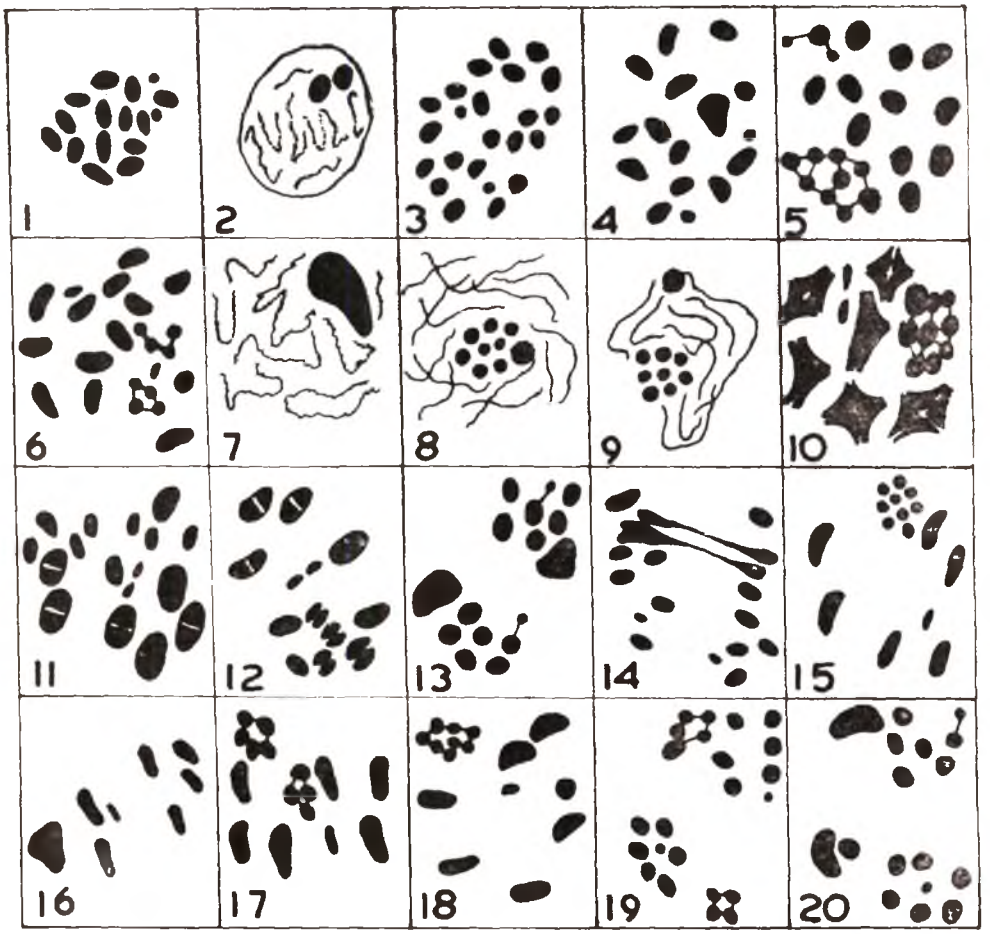
Testes in all sixty male individuals showed uniformly the occurrence of the 9 peculiarly behaving sex chromosomes indicating thereby that the population was a monomorphic one. The supermatogonial prometaphase and metaphase complements contained 23 chromosomes consisting of 12 medium-sized autosomes, 2 minute *m*-chromosomes and 9 sex chromosomes (Figs. 3, 22). The number of autosomes and *m*-chromosomes was constant but the 9 sex chromosomes formed associations in various numercial combinations among themselves making correspondingly the total number of elements also variable in the complements (Figs. 4—6). In some instances 8 of 9 sex elements fused into a single large mass while the 9th element, referred to hereunder as the original *X*, remained somewhat isolated and sometimes showed a little more deeper stain with both Feulgen and haematoxylin (Fig. 4). In other plates all the 9 sex elements were lying close by joined with interchromosomal connections (Fig. 5), or else 8 of 9 sex elements arranged in two (Fig. 6) or more groups. Sometimes the sex elements were distinguishable from autosomes by their slightly more staining intensity, relatively small sizes and somewhat peculiar dispositions. The two *m*-chromosomes were definitely identifiable by their very minute size and

negetively heteropycnotic behaviour. The 9 sex elements in males were recognized as *X* elements because the spermatogonial number was 23 (Fig. 3, 22) against the oogonial number of 16 chromosomes including a pair of *X*s (Fig. 1). The other points in favour of suggesting the extra sex elements being the products of the original single *X* and not *Y*s present in males and missing in females have been discussed afterwards (*vide infra*).

In testes of males the early prophase I contained diffusedly stained thread like bivalents and 9 deeply stained Feulgen positive sex elements (Figs. 8, 9, 23) either fused into a single mass (Fig. 7) or else the original *X* element had an isolated position while 8 other sex elements (*X*s?) formed one (Fig. 9) or more groups as found in spermatogonial metaphases. Late diplotene and diakinesis, nuclei contained 6 autosomal bivalents, two *m*-chromosomes and 9 *X* elements forming various associations (Figs. 10, 24). Typically in polar view of metaphase I, 9 univalent sex chromosomes and 6 autosomal bivalents were found to arrange in the form of ring round the centrally placed *m*-pair (Figs. 11, 25, 26). The nine sex chromosomes also formed various associations (Figs 12, 26, 27) as found in prophase I. Anaphase I seemed to be equational for sex chromosomes though their number moving to each pole was not individually countable because of their crowded dispositions (Figs. 13, 28). Sometimes chromatin bridges between separating chromosomes were seen in this stage (Figs. 14, 29). That the anaphase I was equational for the sex chromosomes was substaniated in some favourable plates of metaphase II which showed 6 autosomes 1 *m*-chromosomes (sometimes obscured for minute size and stain) and 9 *X* elements in various associations (Figs. 15—18, 30, 31). In most plates of metaphase II the sex elements formed a single mass (Figs. 16, 31) or arranged in groups (Figs. 17, 18, 30). In the latter the original *X* generally remained isolated from the other 8 sex elements had variable associations at metaphase II, at anaphase II clear indication of their reductional separation in two groups was shown viz., one with 5 sex chromosomes including the original *X* and the order with 4 *X* elements along with 6 autosomes plus one *m*-chromosome moving to each side (Figs. 19, 32). The critical study of the different plates in late anaphase II indicated that the 4 sex elements moving to one side and 4 among 5 sex elements moving to the opposite side were undergoing gradual degeneration while the original *X* element (one in the 5-element group) included in one daughter nucleus and survived (Fig. 20). This would suggest that 8 out of 9 sex elements were possibly the product of the original *X*. The latter kept its identity not only when extra 8 *X* elements were on their way to dissolution after anaphase II but also in other earlier stages.

DISCUSSION

The sex determining mechanism in *I. limbata* in the population under study was peculiar. WHITE (1973) reviewed other forms of elimination of chromosome or chromatin material in various animals but did not come across the present type. In a few nematodan species of *Ascaris* during the very early cleavage regular elimination followed by ultimate degeneration of the club-shaped terminal ends leavings the holocentric or polycentric chromosomal part destined to pass into the somatic cells was recorded by some workers (WALTON, 1924; WHITE, 1973). The elimination of the terminal heterochromatic segments at the fifth



Camera lucida drawings × ca. 2000. Figs. 1, 2 of females and 3–20 of males. Figs.: 1. Oogonial metaphase with 16 chromosomes. 2. Early primary oocyte, two deeply stained bodies perhaps representing 2 *X*s. 3. Spermatogonial metaphase with 23 chromosomes. 4. Spermatogonial premetaphase showing 8 *X* elements fused into a mass and the original *X* lying close to it. 5. Spermatogonial early metaphase showing 9 *X* elements connected with interchromosomal connections and two *m* chromosomes with one autosome. 6. Spermatogonial early metaphase showing 8 extra *X* elements formed two groups of 4 and the original *X* lying apart. 7. Early spermatocyte prophase I, a big heteropycnotic mass formed possibly by the fusion of 9 *X* elements. 8. Early prophase I showing diffusely stained thread like autosomal bivalents and 9 deeply stained *X* elements. 9. Early prophase I. 8 of 9 *X* elements lying closely while the isolated 9th *X* element possibly represented the original one. 10. Diakinesis, 9 *X* elements closely associated. 11. Metaphase I showing six relatively large autosomal bivalents, the *m* pair, 8 smaller extra *X* elements and the medium-sized original *X*. 12. Metaphase I showing 4 pseudo-pairs formed by 8 extra *X* elements while the unpaired original *X* lying close to them. Centrally placed *m* pair and bivalents are also seen. 13. Anaphase I with 6 autosomes, one *m* and one fused mass formed by the *X*s at each pole. 14. Anaphase I showing chromatin bridges formed possibly by the *X* elements. 15. Metapoase II, 9 closely situated *X* elements, 6 relatively large autosomes and an *m* chromosome. 16. Metaphase II, 9 *X* elements fused into a mass while 6 autosomes and the *m* lying separate. 17. Metaphase II, 8 extra *X* elements formed two groups of 4 besides the original 9th *X* element in one, and six autosomes and the *m* lying free. 18. Metaphase II, 8 extra *X* elements formed a beaded chain, while the original *X* little smaller than 6 autosomes lying apart. 19. Anaphase II showing 5 and 4 sex elements moved to opposite poles along with 6 autosomes and the *m* chromosomes. The larger *X* element in group of 5 in one pole possibly the original *X*. 20. Anaphase II showing dissolution of 4 *X* elements at each pole while the original *X* retained at one side along with 6 autosomgs and the *m* chromosome.

or sixth embryonic cleavage division in the copepod *Cyclops*, reported by BEERMAN (1959) was explained by STICH (1962) as perhaps loss of DNA of chromosomal origin indicating a type of gene amplification mechanism. Elimination of masses of DNA and protein was reported in diapausing *Chironomus* larva at 4th instar stage (KEYL & HAGELE, 1966). In the dipteran *Sciara coprophila*, the paternal chromosomes along with the *X* were seen to be eliminated at the seventh or eighth cleavage division (DU BOIS, 1933). MANNA (1951) also observed the elimination of Feulgen positive 'chromatoid' body which was not an integral part of chromosome itself during spermatogenesis in pentatomid bugs, *Dolycoris indicus*, *Halyomorpha pica*, *Nezara viridula*, *Piezodorus hybneri*, *Scutellera perplexa*, in coreid bug *Elasmomia granulipes*, and in reduvid bug *Sycanus* sp. Among Homoptera, in aphids the single or multiple *X* chromosomes are eliminated at the sexuparae stage of the cyclical parthenogenetic forms (see MANNA 1979). Further, Feulgen negative masses of ribonucleoprotein were regularly left out at anaphase in the mite, *Pediculopsis graminum* (COOPER, 1939) and in the cleaving eggs of some species of Lepidoptera (see WHITE, 1973). In several species of Cecidomyidae a number of 'eliminated' chromosomes of the zygote nucleus were reported to be thrown out during certain cleavage division as laggards and the *E*-chromosomes with their parts and products clumped into pycnotic masses in the yolky cytoplasm (see WHITE, 1973). The pycnotic masses ultimately underwent disintegration by breaking into pieces possibly due to some enzymatic activity as suggested in case of *Ascaris* (BOVERI, 1909, 1910, 1911). Further mutation producing 'fragile sites' has been claimed in chromosomes of man (LEJEUNE, *et al.*, 1968) as well as in grasshopper (WHITE, 1966). Therefore WHITE (1973, page 467) rightly remarked. "The existence of a fundamental similarity between meiotic mechanism of most multicellular organisms should not blind us, however, to the complex evolution which meiosis has undergone and the numerous detailed modification which occur". The origin from the original *X* and the elimination of 8 additional *X* elements in male *I. limbata* were thus one such peculiar modification among various types reviewed by WHITE, (1973). It has been suspected that the same type of sex chromosome origin and elimination is operative in another largid bug, *Macroceroea (Lohita) grandis* (BANERJEE, 1959; MANNA & DEB-MALLICK, unpublished).

Although we are aware of its crucial importance, the exact time of origin and degeneration of 8 additional *X* elements is yet to be found out. We have not yet been able to study the chromosome constitution during the early eleavage following fertilization. It has been suspected that the 8 additional sex elements but not the original *X* showing the sign of degeneration after undergoing reductional division at anaphase II might have completed the dissolution during spermiogenesis or after fertilization. The fresh origin of the additional 8 *X* elements very likely took place as the product of the original *X* in the early cleavage divisions. That the extra 8 *X* elements did not originate by fragmentation of the original *X* would find support from the fact that the size of the single *X* in the Trivandrum population (RAJASEKHARASETTY, 1963) was not large enough to give rise simply by fragmentation to 9 *X*-elements in the present population. Further, their origin solely by non disjunction of the original *X* would be remote as they did neither pair with the original *X* nor were their sizes same.

Partial role of non-disjunction was not, however, ruled out (*vide infra*). It could be speculated that 4 additional *X* elements were the products of the original *X* due to gene amplification, each of which subsequently doubled due to non-disjunctions. This could be supported by the reductional behaviour at anaphase II and sometimes pairing in twos at metaphase I.

Since the spermatogonial chromosome number was 23 and the oogonial number was 16, one could suspect alternatively the sex chromosome mechanism in this species as one *X* and 8 *Y*s in male and *XX* in females because 8 additional sex elements were unaccountable in the oogonial complements. Therefore, we were left to the choice of discarding the possibility of multiple *Y*s and one *X* in males on some more grounds. Firstly, the extra sex elements were undergoing reductional division at anaphase II followed by their degeneration and secondly they did not form the sex pseudo-multivalent structure at metaphase II with the *X* at one side and 8 so-called *Y*s at the other along the poleward direction in the spindle which was normally expected in meiosis of male Heteroptera with multiple sex chromosome mechanism (MANNA, 1951, 1962; RAY CHAUDHURI & MANNA, 1955). The males of this species should not also be considered to have ordinary multiple *X*s without *Y* as found in some other species of Heteroptera (MANNA, 1951, 1957, 1958, 1962) because in such case the oogonial plates in *I. limbata* should have contained 32 chromosomes consisting of 12 autosomes + 2*m* + 18 *X* chromosomes instead of 16 with 2 *X*s only. Having failed to subscribe to include the 8 of 9 sex elements as regular members with their uninterrupted continuity through generations, we were left with no other alternative but to think that their orign took place by chromatin synthesis of the original *X* during early embryogenesis, possibly by the mechanism of gene amplification as suggested by STICH, (1962) on other material. The initial increase of 4 additional sex elements could have multiplied to 8 by non-disjunction as surmised before. However, on this basis the correlation of chromsome behaviour between the present population and that of Trivandrum (RAJASEKHARASETTY, 1963) would be only possible through very complicated evolutionary process because the latter had 2n=23 chromosomes *viz.*, 22 autosomes and one conspicuously large *X*. The spermatogonial number was the same in both the populations but the karyotype in the present population differed

Fig. 21. Oogonial prometaphase with 16 chromosomes. 22. Spermatogonial metaphase with 23 chromosomes. 23. Early prophase I with 9 deeply stained sex elements in close association. 24. Late diplotene with 6 autosomal bivalents, fused sex elements forming a mass while *m* chromosomes obscure. 25. Metaphase I with relatively large 6 autosomal bivalents and 9 smaller *X* elements surrounding the centrally placed *m*-chromosomes. 26. Metaphase I, 4 of 9 *X* chromosomes lying in pairs. 27. Metaphase I, typically *m*-pair at the centre and some *X* elements in paired condition. 28. Anaphase I with 6 autosomes, single *m* chromosome and sex chromosomes at each pole. 29. Anaphase I with chromatin bridges. 30. Metaphase II showing the original *X* lying close to the sex chromosome mass formed by 8 extra *X* elements. 31. Metaphase II showing *X* elements formed a single mass. 32. Anaphase II, one half with 5 and the other with 4 *X* elements though their separate identity not very distinct. Six autosomes and one *m* clear in one side.


21
22
23
24
25
26
27
28
29
30
31
32

radically in the presence of one pair of *m* chromosomes, 9 *X* elements none being exceptionally large and the peculiar behaviour of the *X* Complex. The materials collected from two widely separated places (a distance of 2,600 km) and studied by RAJASEKHARASETTY, (1963) and by us showed so marked cytological differences that they would invite attention of taxonomists first to check up if we were not really dealing with two incipient species. The piece of cytological informations might be more of taxonomic use as incipient species were raised to different species status after the cytological differences were shown in the Heteropteran genera *Thyanta* and *Banasa* (WILSON, 1907; SCHRADER & HUGHES-SCHRADER, 1956, 1958). If the identification of *I. limbata* collected from two widely different populations was correct, we could then suggest the largest *X* of Trivandrum population underwent fragmentation giving rise to the relatively small original *X* (9th element in the present population which was endowed with the property of gene amplification for some functional reason. This function was manifested in the origin of 8 extra *X* elements possibly during very early cleavage divisions and their elimination at the end of spermatogenesis. Further, the origin of the *m* chromosomes could have also taken place from the Trivandrum population to the eastern populations in West Bengal detected by BANERJEE, (1958) and by us. Since each of the three populations appeared to be chromosomally monomorphic, a study of populations in the intermediate zones might reveal some interesting cytological phenomena. That the populations in West Bengal underwent chromosomal evolution through polymorphism was supported by the findings of BANERJEE (1958) as he reported in his material the spermatogonial number of 20 chromosomes including 6 *X*s, no *Y* and a pair of *m*. The population studied by us had three additional *X* elements making the total of 9 *X*s. As the account published by BANERJEE (1958) lacked details and also he and RAJASEKHARASETTY (1963) did not study the chromosome constitution in females, we could not make a thorough comparison. But none-the-less the cytological studies of *I. limbata* still remained interesting for obvious reasons focussed before. Further studies would be carried out in order to detect the time of origin of the extra *X* elements and their elimination cycle, and the survey of other populations.

REFERENCES

BANERJEE, M. R. (1958) A study of chromosomes during meiosis in twenty-eight species of Hemiptera (Heteroptera : Homoptera). *Proc. zool. Soc. (Calcutta)*, **11**, 9—37.

BANERJEE, M. R. (1959) Chromosome elimination during meiosis in the males of *Macroceroea (Lohita) grandis* (GRAY) (Pyrrhocoridae-Heteroptera). *Proc. zool. Soc. (Calcutta)*, **12**, 1—8.

BEERMANN, S. (1959) Chromatin-diminution bei Copepoden. *Chromosoma*, **10**, 504—514.

BOVERI, Th. (1909) Die Blastomerenkerne von *Ascaris megalocephala* and die Theorie der Chromosomenindividualitat. *Arch. Zellforsch.*, **3**, 181—286.

BOVERI, Th. (1910) Die Potenzen der *Ascaris* Blastomeren bei abgeänderter Furchung. *Festschr. f. R. Hertwin.* **3**, 131—214.

BOVERI, Th. (1911) Über das Verhalten der Geschlechtschromosomen bei Hermaphroditismus. Beobachtungen an *Rhabditis nigrovenosa*. *Verh. Phys. med. Oes. Wurzb.*, **41**, 83—97.

COOPER, K. W. (1939) The nuclear cytology of the grass mite *Pediculopsis graminum* (REUT) with special reference to karyomerokinesis *Chromosoma*, **1**, 51—103.

DU BOIS, A. M. (1933) Chromosome behaviour during cleavage in the eggs of *Sciara coprophila* (Diptera) in relation to the problem of sex determination. *Z. Zellforsch.* **19**., 595—614.

KEYL, H. G. & K. HÄGELE (1966) Heterochromatin-proliferation an den Speicheldrüsenchromosomen von *Chironomus melanotus*. *Chromosoma*. **19**, 223—230.

LEJEUNE, J., B. DUTRILLAUX, J. LAFOURCADE, R. BERGER, D. ABONYI & M. O. RETHORE (1968) Endoreduplication du bras long du chromosome 2 chez une femme et as fille. *C. R. Acad. Sci. Paris*, **266**, 24—26.

MANNA, G. K. (1951) A study of the chromosomes during meiosis in forty-three species of Indian Heteroptera. *Proc. zool. Soc. Bengal*, **4**, 1—116.

MANNA, G. K. (1957) Sex mechanism in *Dysdercus*. *Curr. Sci.*, **26**, 187.

MANNA, G. K. (1958) Cytology and inter-relationships between various groups of Heteroptera. *Proc. Xth Intern. Cong. Ent., Canada*, **2**, 919—934.

MANNA, G. K. (1962) A further evaluation of the cytology and inter-relationships between various groups of Heteroptera. *Nucleus*, **5**, 7—28.

MANNA, G. K. (1979) A check-list of chromosome number in aphids with comments. *Proc. Symp Aphidological Researches in India*, Bhubaneswar, June 9—12 (In Press).

MANNA O. K. & S. DEB-MALLICK (1980) Prereductional meiosis in an XO male reduviid bug, *Ectrychotes abbreviatus* KEUT. (Heteroptera). *Entomon*, **5**, 19—23.

MANNA, G. K. & S. DEB-MALLICK (1980) Sex chromosome regeneration and elimination in largid bug, *Mucroceroea* (*Lohita*) *grandis* (Unpublished).

RAJASEKHARASETTY, M. R. (1963) Cytology of *Iphita limbara* (Pyrrhocoridae, Heteroptera). *Caryologia*, **16**, 143—147.

RAY-CHAUDHURI, S. P. & G. K. MANNA (1955) Evidence of a multiple sex-chromosome mechanism in a pyrrhocorid bug, *Physopelta schlanbuschi* FABR. *Proc. zool. Soc. (Calcutta)*. **8**, 65—77.

SCHRADER, F. & S. HUGHES-SCHRADER (1956) Polyploidy and fragmentation in the chromosomal evolution of various species of *Thyanta* (Hemidtera). *Chromosoma*, **7**, 469—496

SCHRADER, F. & S. HUGHES-SCHRADER (1958) Chromatid autonomy in *Banasa* (Hemiptera: Pentatomidae). *Chromosoma*, **9**, 193—115.

STICH, H. F. (1962) Variations of the deoxyribonucleic acid (DNB) content in embryonal cells of *Cyclops strenuus*. *Exc. Cell Res.*, **26** 136—143.

WALTON, A. C. (1924) Studies on Nematode gemetogenesis. *Z. Zell.-u. Gewebel.*, **1**, 167—239.

WHITE, M. J. D. (1966) A case of spontaneous chromosome breakage at a specific locus occurring at meiosis. *Aust. J. Zool.*, **14**. 1027—1034.

WHITE, M. J. D. (1973) *Animal Cytology and Evolution*. 3rd Edition. University Press, Cambridge.

WILSON, E. B. (1906) Notes on the chromosome group of *Musedivio* and *Banasa*, *Biol. Bull.* **16** 303

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 297 *to* 305

ON THE POPLAR INHABITING APHIDS (HOMOPTERA: APHIDIDAE) OF INDIA AND ADJOINING COUNTRIES WITH NOTES ON SOME SPECIES

S. P. MAITY & S. CHAKRABARTI

Entomology Laboratory, Department of Zoology, University of Kalyani, Kalyani, India 741 235

(Received 25 August 1980)

A comprehensive account of 21 so far known aphid species infesting *Populus* spp. in India and adjoining countries (Pakistan and Afghanistan) has been provided. A key to these species has been made. *Pemphigus mordvilkoi* Cholodkovsky has been redescribed from the available material.

(Key words: aphids, poplar plants, taxonomy, morphology, India)

Poplar (*Populus* spp.) is one of the important ornamental avenue and forest trees in India. There are 4 species of *Populus viz.*, *P. alba* Linn. (between altitudes *c* 1700m and *c* 2100m), *P. ciliata* Wall. (between altitude *c* 1700 m and *c* 2200 m), *P. euphratica* Oliv. (altitudes upto *c* 4000 m) and *P. nigra* (between altitude *c* 1700 m and *c* 1900m) found in this region. Although the different species of poplars are of common occurrence in north western part of the Himalayas, these can hardly be found in wild state in some parts of Sikkim and Darjeeling district of West Bengal under the north east Himalaya.

Our knowledge on poplar infesting aphids in India and adjoining countries is rather scattered and incomplete. Habib & Ghani (1970) provided an account of 14 species occurring in Pakistan and Afghanistan. Mani (1973) has given an account of 5 species of aphids producing galls on *Poplar* spp. and Ghosh (1974) listed 3 species of aphids infesting poplar trees. In addition, a number of scattered works reporting one or two species are available on the aphids inhabiting *Populus* spp. in this region.

Considering the above information, the poplar plants are infested by 21 species of aphids of which 4 species belong to the subfamily Chaitophorinae, 1 species to Hormaphidinae, 14 species to Pemphiginae and the remaining 2 species are under the subfamily Pterocommatinae. All the members of Pemphiginae except *Phloeomyzus passerinii* (Signoret) have been found to produce galls on different parts of the host plant Six species under Pemphiginae have been excluded from the key because of lack of either sufficient report or description of respective species. However, 3 species *viz.*, *Pemphigus kashmiricus* Rishi (1979), *Pemphigus ignotus* Habib and Ghani (1970) and *Pemphigus venosus* Habib and Ghani (1970) are really *nomen nudum*. *Doraphis? populi* (Maskell) (David *et al.*, 1971; Rishi, 1979), *Pemphigus spirothecae* Passerini and *Pemphigus vesicarius* Passerini (Habib & Ghani, 1970) could not be incorporated in the key since neither the specimens of the above collections nor sufficient other informations of this species are presently at hand.

So, an attempt is made here to provide a rather comprehensive account of the aphids found on different poplar trees in India and adjoining countries covering Western Himalaya namely Pakistan and Afghanistan. Besides the account of species occurring on poplar, a key to the species has been provided for easy identification of aphids. In addition, hitherto little known aphid species, *Pemphigus mordvilkoi* Cholodkovsky has been redescribed from the material collected from the area.

SYSTEMATIC ACCOUNT

1. Chaitophorus dorocola Matsumura, 1919, *Trans. Sapporo Nat. Hist. Soc.*, 7:113. Higuchi, 1972. *Ins. Matsumurana*, 35:83 Chakrabarti, 1977. *Oriental Ins.* 11:208.

Materials examined : 2 apterae and 2 alatae, INDIA : WEST BENGAL, Darjeeling, Kalimpong, 2. ii. 1971 from? *Populus* sp. (coll. M. R. Ghosh).

Remarks: This species has so far been collected once only from a plant possibly poplar from north easten part of India. This species is known to infest *Populus maximowiczii* and *P. sieboldi* in Japan (Higuchi, 1972).

2. Chaitophorus indica Ghosh, M. R., Ghosh, A. K. and Raychaudhuri 1970. *Oriental Ins.* 4:196; Chakrabarti, 1977. *Oriental Ins.* 11:208.

Materials examined: Many apterae, INDIA : WEST BENGAL, Darjeeling district, October to April 1969—1972 from *Populus* sp. (?) (Coll. M. R. Ghosh).

Remarks: This species has so far been reported from north east Himalaya. Chakrabarti (1977) provided an account of material collected from Darjeeling, Kalimpong, Tashiding, Durbin and Kamsi (West Bengal). This species is found in cluster on the under surface of both young and matured leaves.

3. Chaitophorus kapuri Hille Ris Lambers, 1966. *Tijdschr. Ent.*, 109:197; Kumar, 1973. *Oriental Ins.* 7:11; Chakrabarti, 1977. *Orien al Ins.* 11:210.

Materials examined: 1 aptera (paratype) INDIA : HIMACHAL PRADESH, Manali 25.vi.1955 from *Populus* sp. (coll. A. P. Kapur); 1 alata, Himachal Pradesh, Simla, 4.v.1972 from yellow pan water trap (coll. A. N. Choudhuri).

Remarks: This species is found in cluster both on the upper and under surface of leaves. Ants were found to attend these aphids. This species is known from north west Himalaya including parts of Pakistan.

4. Chaitophorus populeti (Panzer) *Aphis populeti* Panzer, 1805. *Fauna Insectorum Germaniae initia oder Deutschlands Insectan*, 95:6, *Chaitophorus populeti* (Panzer). Szelegiewicz, 1967. *Fragmenta faunistica*, 14:62; Verma; 1969. *Sci. Cult.*, 35:28; Chakrabarti. 1977. *Oriental Ins.* 11:210.

Materials examined: 2 apterae, INDIA: JAMMU and KASHMIR. Srinagar, 5. v. 1966 from *Populus alba* (coll. K. D. Verma).

Remarks: This species in India is known to infest *Populus alba* in Kashmir, Himalaya.

5. Epipemphigus imaicus (Cholodkovsky) *Pemphigus imaicus* Cholodkovsky, 1912. *Rev. Russ. Ent.*, 12:495 *Epipemphigus imaicus* (Cholodkovsky); Hille Ris Lambers, 1966. *Tijdschr. Ent.* 109:205; Chakrabarti, Ghosh, A. K. and Chowdhuri, 1970. *Oriental Ins.*, 4:449.

Materials examined: Many apterae, alatae and nymphs, INDIA: UTTAR PRADESH, Chaubattia, 29. v. 1969; Mussoorie, 20.vi.1975; Gobindaghat, 13. vi. 1978 from *Populus* sp. (coll. S. Chakrabarti); Mussoorie, 21. vi. 1976, 19. x. 1976 (coll. S. P. Maity); Himachal Pradesh, Simla, 16. vi. 1979 (coll. D. K. Bhattacharya).

Fig. 1 Leaf gall on *Populus ciliata* by *Epipemphigus imaicus* (Cholodkovsky)

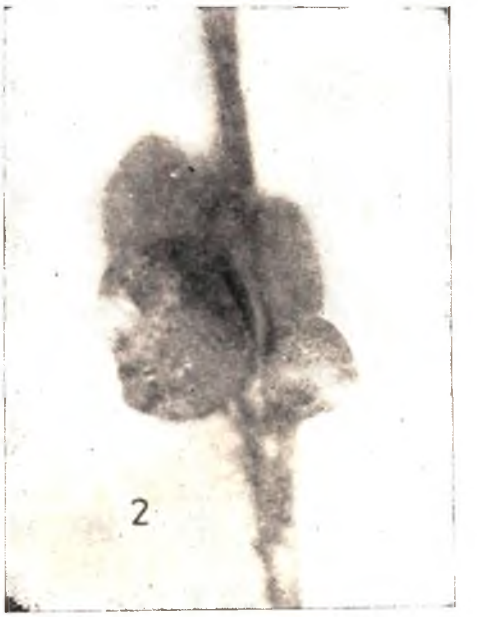


Fig. 2. Stem gall on *Populus ciliata* by *Pemphigus mordvilkoi* Cholodkovsky.

Fig. 3. Leaf base gall on *Populus* sp. by *Pemphigus* sp.

Remarks: This species is found on poplar galls from march to July in North West Himalaya. Recently, it has also been collected from Sikkim Himalaya infesting poplar (Dr. P. K. Mondal, personal communication). Hille Ris Lambers (1966) mentioned that the alate viviparous female (emigrant) is devoid of wax plates on thorax. A series of specimens collected by the authors however shows wax plates spinally on metathoracic segment. Either only single aptera and many nymphs or many alatae (emigrants) and nymphs with waxy covering were noticed in one gall.

6. Eriosoma (Schizoneura) lanuginosum (Hartig) *Schizoneura lanuginosum* Hartig, 1939. In *Germars' Z. Entomol.*, 3: 359—376.

Eriosoma (Schizoneura) lanuginosum (Hartig. Eastop and Lambers, 1976. Survey of the World's Aphids, 192.

Remarks: Ghulamullah (1942) described this species as *Eriosoma taskhiri.* Mani (1973) mentioned the distribution of *taskhiri* in India (Kashmir), Pakistan and Afghanistan. Eastop & Hille Ris Lambers (1976) considered *E. taskhiri* Gulamullah as a synonym of *Eriosoma (Schizoneura) lanuginosum* (Hartig). The authors could not collect any material of this species.

7. Pemphigus immunis Buckton, 1896. *Indian Mus. Notes*, 4: 51; Doncaster, 1969. *Proc. R. ent. Soc. Lond. (B).*, 38: 158; Hille Ris Lambers, 1973. *Oriental Ins.*, 7:244.

Remarks: Doncaster (1969) while redescribing this species listed its synonyms and discussed the host relationship of this species. Hille Ris Lambers (1973) through transfer experiments confirmed that *Euphorbia helioscopia* and *E. peplus* are the secondary hosts of this aphid. The authors could not collect this aphid from any of these plants.

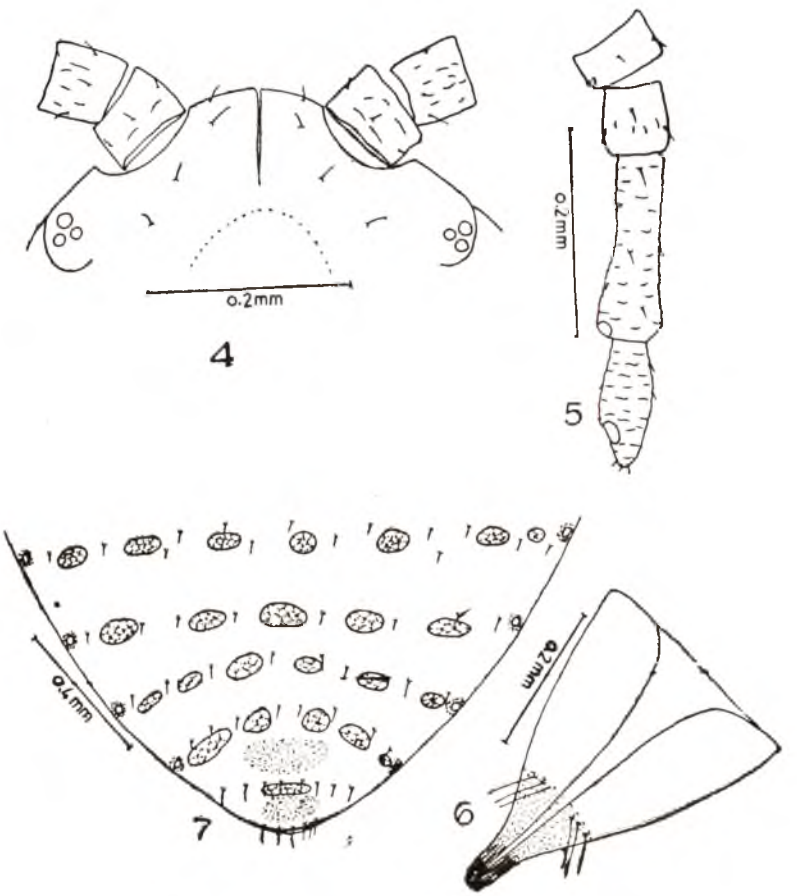
8. Pemphigus mordvilkoi Cholodkovsky, 1912. *Rev. Russ. Ent.*, 12:493.

Materials examined: Many apterae, alatae and nymphs, INDIA: UTTAR PRADESH, Chaubattia, 29.v. 1969 from *Populus* sp. (coll. S. Chakrabarti); Mussoorie from *Populus* sp. 21. vi. 1976, 19. x. 1976 (coll. S. P. Maity).

Remarks: Since the description of this species by Cholodkovsky (1912) no further information is available. Moreover, the description of this species is incomplete in the light of recent trends in aphid taxonomy. Hence, this species is redescribed from its primary host plant.

Morphological description:

Fundatrix (Figs. 4—7): Body 2.38—2.86mm long with 1.56—2.48mm as maximum width. Head pale brown to brown, dorsum with incomplete median suture, slightly rugose, bearing 8 pairs of short and fine hairs, longest hair on vertex about 0.38—0.53 times as long as the basal diameter of the antennal segment III. Antenna 4-segmented, pale about 0.16—0.18 times as long as body, segements I and II scabrous, segments III and IV with rows of spinules scattered through out the length; processus terminalis about 0.14—0.23 times the base af segment VI; hairs on flagellum very short with acute apices, longest one on segment III about 0.30—0.38 times the basal diameter of the segment. Rostrum reaching mid-coxae, ultimate rostral segment about 0.55—0.65 times the second joint of hind tarsus. Thorax pale, with 6 wax plates arranged in 3 rows placed marginally, pleurally and spinally. Abdomen pale, tergites 1—7 with marginal, pleural and spinal and 8th tergites with spino-pleural wax plates, dorsal abdominal hairs short, longest one on anterior targites about 0.46—0.53 times the basal diameter of the antennal segment III

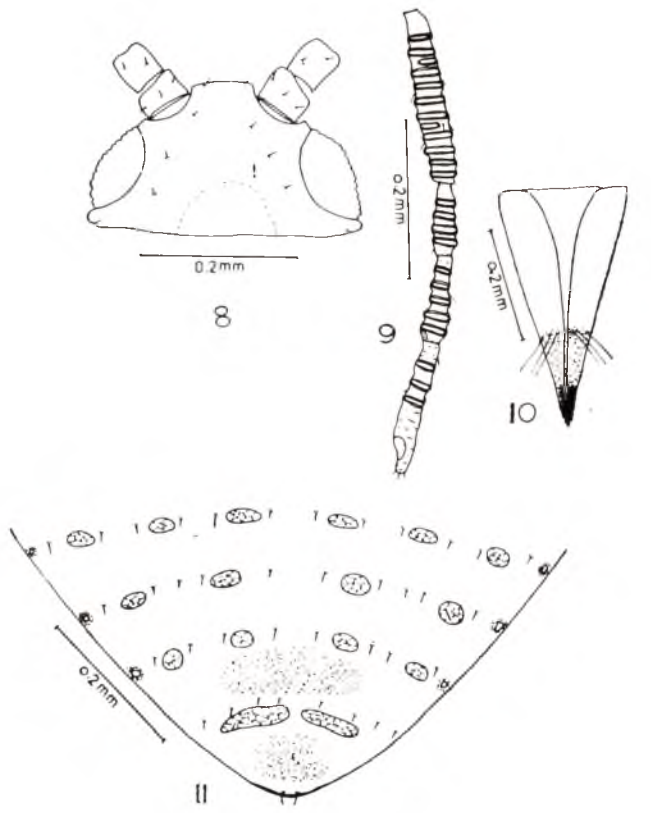


Figs. 4—7. *Pemphigus mordvilkoi* Cholodkovsky, Fundatrix : 4. head 5. antennal segments, 6. ultimate rostral segments, 7. posterior portion of abdomen.

and those on 7th and 8th tergites about 0.64—0.70 times and 0.72—0.93 time the mentioned diameter, respectively. Siphunculi absent. Cauda semioval with 6—7 hairs. Legs brown, empodial hairs thick, short and about $\frac{1}{3}$ length of the claw. First tarsal chaetotaxy 2, 2, 2.

Measurements of one specimen in mm: Body length 2.68, width 2.04; antenna 0.46; antennal segments I : II : III : IV: 0.08 : 0.06 : 0.19 : (0.9+0.03); ultimate rostral segment 0.10; second joint of the hind tarsus 0.15.

Alate viviparous female (Emigrant) (Figs. 8—11): Body about 2.23—2.48mm long with 0.92-1.07 mm as maximum width. Head with 4 pairs of short hairs. Antennae 6-segmented,about 0.31—0.34 times the body; segment III with 12—14, IV with 3—4, V and VI with 3—5 secondary rhinaria distributed over the entire length of the segments; longest hair on segment III about 0.40—0.60 times the basal diameter of the segment. Ultimate rostral segment about 0.44—0.47 times the second joint of hind tarsus. Thorax with marginal, pleural and spinal wax plates. Abdomen pale; dorsal



Pemphigus mordvilkoi Emigrant (Alata) : 8. head, 9. antennal segments, 10. ultimate rostral segment, 11. posterior portion of abdomen.

hairs short with acute apices, longest one on anterior tergites about 0.66—1.0 times the basal diameter of segment III, 8th tergite with 2 spino-pleural wax plates. Cauda semioval with 2 hairs. Fore wing with media simple; hind wing with 2 obliques arising nearly from a point. Other characters as in fundatrix.

Measurements of one specimen in mm: Body length 2.45, width 1.04; antenna 0.77; antennal segment III : IV : V : VI : 0.25 : 0.10 : 0.11 (0.14 + 0.03); ultimate rostral segment 0.08; second joint of hind tarsus 0.17.

9. Pemphigus nainitalensis Cholodkovsky, 1912 *Rev. Russ. Ent.*, 12:494.

Remarks: From the name of the species it appears that this species was collected in Nainital (Uttar Pradesh) from poplars No further information on this species is available and hence the description of gall is included in the key.

10. Pemphigus napaeus Buckton, 1896. *Indian Mus. Notes*, 4:51; Doncaster, 1969. *Proc. R. ent, Soc. Lond.* (B).. 38:160.

Remarks: Buckton (1896) originally described this species and later Doncaster (1969) redescribed in full and discussed the relationship of this species. The authors could not examine any material of this species.

11. Pemphigus siphunculatus Hille Ris Lambers, 1973. *Oriental Ins.*, 7: 245.

Remarks: Hille Ris Lambers (1973) described the species forming galls on the twigs of *Populus ciliata* in Murree, Pakistan. This species could not be collected in the Indian parts of north west Himalaya.

12. Pemphigus sp.

Materials examined; 2 apterae and nymphs, INDIA: UTTAR PRADESH, Ghangaria, 10. vi. 1978 from *Populus* sp. (coll. S. Chakrabarti).

Remarks: Cystolith shaped, reddish green leaf base gall of poplar found in some parts of Garhwal Himalaya. Each gall contained a fundatrix and some immature nymphs. The identification of the aphid material beyond the generic level is not possible at present.

13. Pterocomma populifoliae (Fitch) *Aphis populifoliae* Fitch, 1851. *Annu. Rep. N. Y. State Cab. Natur. Hist.*, 4: 66.

Pterocomma populifoliae (Fitch), Szelegiewicz. 1965. *Ann. Zool. Agra.*, 23: 295; MacGillivray, 1955. *Can. Ent.*, 87: 336; Richards, 1967. *Can. Ent.*, 99: 1022; Ghosh, M. R., Ghosh, A. K. and Raychaudhuri, 1970. *Oriental Ins.*, 4: 388; Chakrabarti, Chowdhuri and Raychaudhuri, 1974. *Sci. Cult.*, 40 : 461.

Materials examined: 3 apterae, 1 alata INDIA: KALIMPONG, 2. iv. 1969 from *Populus* sp. (coll. M. R. Ghosh); 1 alata (vagrant), Mashobra, Simla, 30. iv. 1972 (coll. A. N. Chowdhuri).

Remarks: This species has been reported to infest *Populus* sp. in north east India. It has also been collected from North west India. Richards (1967) dealt with this species in detail and clearly mentioned that the species usually infest roots of *Populus* sp. and occasionally infest the aerial portions of its hosts.

14. Pterocomma populeum (Kaltenbach) *Aphis populea* Kaltenbach, 1843. *Mon der Fam. Pflanz.*, 116. *Pterocomma populeum* (Kaltenbach); van der Goot, 1917. *Rec. Indian Mus.*, 13: 175; Richards, 1967. *Can. Ent.*, 99 : 1025.

Remarks: Van der Goot (1917) reported this species from Kumaon Himalaya. Further records of this species from India is not available. Richards (1967) dealt with this species in detail and the characters used in the key to the species have been taken from there.

Species not included in the key :

15. Doraphis? populi (Maskell) reported by David *et al.* (1971) and Rishi (1979)

16. Pemphigus ignotus Habib and Ghani (1970) *nom. nud.*

17. Pemphigus kashmiricus Rishi (1979) *nom. nud.*

18. Pemphigus spirothecae Passerini reported by Habib and Ghani (1970).

19. Pemphigus venosus Habib and Ghani (1970) *nam. nud.*

20. Pemphigus vesicarius Passerini reported by Habib and Ghani (1970) *nom. nud.*

21. Phloeomyzus passerinii (Signoret reported by Habib and Ghani (1970).

KEY TO THE SPECIES INFESTING POPLARS IN INDIA AND ADJOINING COUNTRIES

1. Aphids form galls on aerial parts of plants 2

—Aphids never form galls 9

2. Galls found on stem or twig 3

—Galls found on leaf 6

3. Galls found on twigs and leaves, roundish or irregular, sessile, shining green, variegated with yellow or brown spots, distinctly veined; fundatrices with antennae, 5-segmented; siphunculi absent; cauda with 2 hairs; wax plates present on meso- and

metathorax and on abdominal segments, on abdominal segments 1—7 each with a pair of spinal, pleural and marginal wax plates ..... *Pemphigus napaeus* Buckton.

—Galls never veined as above 4

4. Galls found on twig; apterae with antennae 6-segmented, sometimes 5 segmented; siphunculi dark, ring shaped, without rim; wax plates absent on thorax, present only on abdomen, abdominal segments I and III without spinal wax plates, pleural wax plates absent on segments I and II and marginal ones absent on segment VII; alatae not known..... *Pemphigus siphunculatus* Hille Ris Lambers.

—Galls found on twig or stem; apterae with antennae 4-segmented; siphunculi absent; wax plates present on thorax 5

5. Galls found on stem (Fig. 1) which are spherical, thick-walled, sessile, yellow or yellowish green, smooth, usually solitary, 10—30 mm in diameter with large gall chamber; wax plates present on thorax and on abdomen in apterae; in alatae antennal segments III with 12—14, IV with 3—4, V and VI with 3—5 secondary rhinaria; ultimate rostral segment about 0.44—0.47 times the second joint of hind tarsus; cauda with 4 hairs ..... *Pemphigus mordvilkoi* Cholodkovsky

—Sub-spherical, smooth, small, sessile, lateral 1—2 per branch, 5—7mm in diameter, much smaller than *Pemphigus mordvilkoi* ..... *Pemphigus nainitalensis* Cholodkovsky

6. Galls with a stalk or some times with a neck-like structure at base, epiphyllous, ovoid, clavate, sometimes laterally compressed and lopsided with a short narrow neck, reddish brown, rugose and finely pubescent; aphids with wax plates present on head, thorax and on abdomen, composed of wax cells surrounding a central space, without any hair; siphunculi ring like ..... *Eriosoma (Schizoneura) lanuginosum* (Hartig)

—Galls never with a stalk or neck-like structure at base; aphids with wax gland cells around the central space, with or without hair; siphunculi mostly absent or preseut as indistinct ring 7

7. Galls (Fig. 3) found on the dorsal surface near leaf base, of somewhat cystolith shaped raddish green ..... *Pemphigus* sp.

—Galls never at leaf base dorsally 8

8. Galls (Fig. 2) elongately cylindrical, fleshy epiphyllous, reddish green in colour, usually along the midrib, with an elongated opening on the ventral side, either with single aptera and many nymphs in waxy powder or with numerous alatae and nymphs in waxy covering in each gall; aphids without hair on wax plates; fundatrices without any wax plates ..... *Epipemphigus imaicus* (Cholodkovsky)

—Galls fusiform, woody, hard, dehiscent, often deeply furrowed; aphids with hair on wax plates, alatae with large primary rhinaria on antennal segment V ..... *Pemphigus immunis* Buckton

9. Siphunculi cylindrical to distinctly swollen, always longer than width at base, non-reticulated; dorsal abdominal pigmentation usually restricted to last 3 or 4 segments in apterae; alatae with frontal and median tubercles, antennal segments III and IV with secondary rhinaria, cauda and sub-anal plate rounded 10

—Siphunculi truncate, hardly longer than width at base, reticulated at least near apices 11

10. First tarsal segments with 5, 5, 5 hairs; siphunculi with distinct, dispersed imbrications in addition to usual apical striae; antennal segment III with 0—25 secondary rhinaria in apterae; in alatae segments III with35—50, IV with 0—7 secondary rhinaria inalatae ..... *Pterocomma populifoliae* (Fitch)

—First tarsal segments with 5, 5, 4 hairs; siphunculi smooth in addition to usual apical striae, antennae without secondary rhinaria in apterae, antennal segments III and IV with 0—1 secondary rhinaria in alatae ..... *Pterocomma populeum* (Kaltenbach)

11. Dorsal body hairs in apterae mostly with furcated apices; tergum smooth; ultimate rostral segment 1.0—1.4 times as long as the second joint of hind tarsus and with 6—10 hairs in apterae with pseudosensoria-like structure on hind legs; ultimate rostral segment distinctly longer (more than 1.4 times) than the second joint of

hind tarsus; abdominal dorsum sparsely spinulose on sclerotic parts ..... *Chaitophorus populeti* (Panzer)

—Dorsal body hairs in apterae with blunt, fine or flagellate but never with furcated apices; alatae with normal hind legs; ultimate rostral segment as long as the second joint of hind tarsus 12

12. First tarsal segments with 5 hairs; apterae with 4 pairs of secondary hairs on ultimate rostral segment; longest hair on antennal segment III about 1.8—2.0 times as long as the basal diameter of the segment; alatae with fuscus wing veins; processus tarminalis about 3.0—3.70 times as long as the base of the segment VI; longest hair on segment III about 1.70—2.80 times as long as the basal diameter of the segment, segment III with 10—12 secondary rhinaria ..... *Chaitophorus indica* Ghosh, Ghosh and Raychaudhuri

—First tarsal segment with 6 hairs 13

13. Dorsum of abdomen in apterae pale; processus terminalis about 2.70 times as long as the base of segment VI. Ultimate rostral segment with 4 secondary hairs; alatae with wing veins never fuscus; antennal segments III with 16—18, IV with 1 - 4 secondary rhinaria, longest hair on antennal segment III about 2.0 times as long as the basal diameter of the segment ..... *Chaitophorus dorocola* Matsumura

—Dorsum of abdomen in apterae dark pleurally and pale medially, with some scattered spinules; processus terminalis about 3.0 times as long as the base of segment VI; ultimate rostral segment with 2—4 secondary hairs in apterae; alatae with wing veins slightly to distinctly fuscus; antennal segment III with 10—12 secondary rhinaria, longest hair on segment III about 3.50 times as long as the basal diameter of the segment ..... *Chaitophorus kapuri* Hille Ris Lambers

Acknowledgement:—The authors thank the Head, Department of Zoology, University of Kalyani, for laboratory facilities.

REFERENCES

BUCKTON, G. B. (1896) Note on two new species of gall-aphids from the north-western Himalyan region. *Indian Mus. Notes*, **4**, 50—51.

CHAKRABARTI, S. (1977) Chaitophorinae (Aphididae : Homoptera) of India with descriptions of three new species from North West India. *Oriential Ins.*, **11** (2), 205—224.

CHOLODKOVSKY, N. (1912) Sur des chermes de la suisse. *Rev. Russ Ent.*, **12**, 491—496.

DAVID, S. K., K. NARAYANAN & S. G. RAJASINGH (1971) Records of aphids in India. *Madras agric. J.*, **58** (5), 372—374.

DONCASTER, J. P. (1969) Some species of *Pemphigus* (Homoptera : Aphididae) described from Indian region by G. B. Buckton. *Proc. R. ent. Soc. Lond.* (B)., **38** (11—12), 157—164.

EASTOP, V. F. & D. HILLE RIS LAMBERS (1976) *Survey of the World's Aphids*. Dr. W. Junk b. v. Publishers, The Hague, 1—573.

GHOSH, A. K. (1974) Aphids (Homoptera : Insecta) of economic importanee in India. *Indian agric.*, **18** (2), 81—214.

GOOT VAN DER, P. (1917) On some undescribed aphids from the collection of the Indian Museum. *Rec. Indian Mus.*, **13**, 1—4.

HABIB, R. & M. A. GHANI (1970) Eriosomatinae on Poplars and their natural enemies in West Pakistan. *Tech. Bull. Commonwealth Institute* for *Biol. Control*, **13**, 43—58.

HIGUCHI, M. (1972) A taxomomic study of the subfamily Callipterinae in Japan (Homoptera Aphididae). *Ins. Matsumurana*, **35** (2), 19-12.

HILLE RIS LAMBERS, D. (1973) Notes on some oriental aphids, with descriptions of a new genus and four new species (Homoptera : Aphididae). *Oriental Ins.*, **7** (2), 239—258.

HILLE RIS LAMBERS, D. (1966) New and little known aphids from Pakistan (Homoptera : Aphididae). *Tijdschr. Ent.*, **109**, 193—220.

MANI, M. S. (1973) *Plant galls of India*. Macmillan India, 1—354,

RICHARDS, W. R. (1967) The *Pterocomma* of Canada and Greenland with notes on the phyletic position of the Pterocommatin (Homoptera : Aphididae). *Can. Ent.*, **99**, 1015—1040.

RISHI, N. D. (1979) Additional records of aphid fauna (Homoptera : Aphididae) from Jammu and Kashmir (India). Symposium on Recent Trends in Aphidological Studies, Bhubaneswar, 52.

Entomon, 1981, *Vol.* 6, *No.* 4, *pp* 307 *to* 309

OBSERVATIONS ON THE RELATIONSHIPS BETWEEN BODY LENGTH, BREADTH AND WEIGHT OF TWO PINE APHIDS

M. VIKRAM REDDY[1] & J. R. B. ALFRED

North Eastern Hill University, Department of Zoology,
School of Life Sciences, Shillong - 793 014

(Received 16 September 1980)

Coefficient and multiple correlationships between body length, breadth and weight (wet) of two aphids *viz.*, *Cinara attrotibialis* David and Rajasingh, and *Eulachnus thunbergii* Wilson feeding on pine seedlings *(Pinus kesiya* Royle), were analysed These relationships were found to be statistically positive and highly significant ($P < 0.01$) in both aphids which indicated that these body traits are positive functions of each other, and were discussed.

(Key words: Pinus kesiya, pine aphids, *Cinara attrotibialis*, *Eulachnus thunbergii*, body length, breadth, wet weight)

INTRODUCTION

Biomass of insect consumers in any ecosystem plays a significant role in its function. Often it becomes difficult to obtain the biomass of smaller insects occupying the ecosystem, which can be estimated from the relationship between body length and weight (HUXLEY, 1924; BERTHET, 1967; KAUFMAN & BEYERS, 1972). Moreover many ecological studies concerning the energy estimation and nutrient cycling can be assisted from these relationships (LEE *et al.*, 1976). Information on length, breadth and weight relationships of insects especially aphids bred in natural conditions is very scanty. Thus attempt was made to correlate these body traits of natural populations of aphids *viz.*, *Cinara attrotibialis* DAVID & RAJASINGH and *Eulachnus thunbergii* WILSON feeding on pine *(Pinus kesiya* ROYLE) seedlings.

[1] Present address (reprint request): North Eastern Hill University, College of Agriculture, Medziphema - 797 106 Nagaland, India.

MATERIALS AND METHODS

Weekly samples of aphids were collected along with the pine seedlings during 1976—1977 from one year old pine plantation growing at Raikhan area near Mawlai, Shillong, North Eastern India. More than 3,000 individuals belonging to different instars were measured for their length, breadth and wet weight with the help of an ocular micrometer and a single pan electrobalance accurate to 0.01mg respectively. Measurements were recorded within 24 hours of collection. For statistical analyses methods outlined by WOOLF (1968) were followed.

RESULTS AND DISCUSSION

In *C. attrotibialis* the body length ranged from 0.93 to 3.67mm, the breadth from 0.57 to 2.25mm and weight from 0.05 to 5.7mg. In *E. thunbergii*, the range of the body length was 0.93 to 2.47 mm; breadth was 0.28 to 0.76 mm and weight was 0.28 to 0.7 mg. These data were subjected to linear regression.

As indicated in Table 1, all the regressions were highly significant (<0.01). It was seen that in *C. attrotibialis*, the

TABLE 1. Coefficient correlation and regression equations of three metric traits of each of the two pine aphids.

Species	Metric traits	Regression equation	Coefficient correlation	Level of Significance
1. *Cinara attrotibialis*	Length & Breadth	B′ = 0.56L−4.53 L′ = 1.60B + 18.15	LB = +0.97	P < 0.01
	Length & Weight	W′ = 0.04L−0.709 L′ = 30.64W + 92.25	LW = +0.99	P < 0.01
2 *Eulachnus thunbergii*	Length & Breadth	L′ = 1.4B + 59.39 B′ = 0.37L−2.14	LB = +0.73	P < 0.01
	Length & Weight	W′ = 0.023L−2.24 L′ = 28.38W + 104.24	LW = +0.80	P < 0.01

(L = Length; B = Breadth; and W = Weight. L′, B′ and W′ represent the predicted values)

predicted length increased 1.6 units for every unit increase in breadth and the predicted breadth increased 0.56 units for every unit increase in length. Further more, in the length and weight relationship, the predicted weight increased 0.04 units for every unit increase in body length and the predicted length increased 30.64 units for every unit increase in weight. In *E. thunbergii* similar relationships were observed. The predicted length increased 1.4 units for every unit increase in breadth and the predicted breadth increased 0.37 unit for every unit increase in length. These relationships were highly significant and indicated that the body length, breadth and weight were positive function to each other. Moreover, the multiple correlation coefficient values obtained for these body traits of *C. attrotibialis* and *E. thunbergii* were 0.9764 and 0.7976 respectively which were also statistically significant. BILAPATE *et al.* (1978) reported the mean values of multiple correlation coefficient in male and female pupae of *Heliothis armigera* to be 0.696 and 0.789 respectively. Since all the regression equations are statistically highly significant the prediction made above may be reliable. Hence the biomass (wet) of these two aphids could be predicted directly from the body length and breadth measurements alone.

PRZIBRAM & MEGUSOR (1912) reported that the weight of an insect was doubled during each instar and at each moult all linear dimensions were increased by a ratio of 1.26. This may safely be applied for the increase in weight of the insect larvae in successive stages (MOHAN RAO & TONAPI, 1970). During the present investigation as no attempt was made to trace out the length and weight limits of different instars of these aphids, it is hardly possible to comment on Przibram's rule. However, the weight increase for every unit increase in body length was evident from the Table 1 in both the cases of these two aphids. These values may not be equivalent to those suggested by PRZIBRAM. However, HARRIES & HENDERSON (1938) reported that the

variation shown in the value of the progression factor for the growth of insect is too great to provide any support for the Przibram's theory that the constant has the same value (1.26) for different species. (BILAPATE *et al.*, 1978).

Acknowledgements:—The authors are thankful to Dr. M. L. H. KAUL for the statistical treatment of the data, and to Prof. Dr. R. G. MICHAEL, Zoology department, School of Life Sciences, N. E. H. U., Shillong for providing necessary facilities and going through the manuscript.

REFERENCES

BERTHET, P. (1968) The metabolic activity of Oribitid mites (Acarina) in different forest floors, 709—725, *in: Secondary Productivity of Terrestrial Ecosystems*, Vol. **2**, (ed. PETRUSEWITZ,K.) Warszawa—Krakow, Poland.

BILAPATE, G. G., V. M. PAWAR & A. K. RAODEO (1978) Biometrical analysis of growth in the larvae of *Heliothis armigera* HUBNER. *Proc Indian Acad. Sci.*, **87 B** (*Anim. Sci.* 44), **4**, 349—355.

HARRIES, W. & T. HENDERSON (1938) Growth of insects with reference to progression factors for successive growth stages. *Ann. ent. Soc. Am.*, **31**, 557—572.

HUXLEY, J. S. (1924) Constant differential growth ratios and their significance. *Nature*, **114**, 895—896.

KAUFMAN, G. A. & R. J. BEYERS (1972) Relationship of weight, length and body composition in Medaka, *Oryzias latipes*. *Amer. Midl. Natl.*, **88**, 239—245.

LEE, E. R., W. T. HINDS & R. L. BUSCHBOM (1976) A general weight *vs* length relationship for insects. *Ann. ent. Soc. Am.*, **69**, 387—389.

MOHAN RAO, H. N. & G. T. TONAPI (1970) A biometrical analysis of growth in the larvae of *Dineutes indicus* AUBE. (Gyrinidae : Coleoptera). *Indian J. Ent.*, **32**, 39—50.

PRZIBRAM, H. & F. MEGUSOR (1912) Waschstumsmessungen auf *Sphodromantis bioculata* BURM. *Ann. ent. Soc. Am.*, **31**, 572. (Original not seen).

WOOLF, C. M. (1968) *Principles of Biometry*, D. Von Nostrand & Co. Inc., London.

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 311 *to* 316

AERODYNAMIC PARAMETERS AND FLIGHT CHARACTERISTICS OF A BUTTERFLY, THE TAWNY COSTER, *TELCHINIA VIOLAE* (FABRICIUS)

SASADHAR DE

15, Ratanpalli, Santiniketan, Birbhum, W. Bengal, India - 731 235

&

B. T. DAS

Department of Zoology, Visva-Bharati, W. Bengal

(Received 28 June 1980)

The aerodynamic parameters of the tawny coster, *Telchinia violae* (Fabricius) are determined to study the flight characteristics and power requirements. No correlation is found to exist between wing loading and aspect ratio. Moment of inertia of the wing has been determined for understanding of wing motion. Calculation shows that the butterfly wing represents more or less a flat surface. Various particular cases in connection with the flight dynamics of this butterfly are shown.

(Key words: aerodynamic parameters, tawny coster *(Telchinia violae)*, power, descent or sinking speed, efficiency)

INTRODUCTION

The flight mechanism of insects differs from those of birds and bats anatomically, and physiologically. The flight dynamics of birds, bats and some of the insects have been studied among others by PENNYCUICK (1975), VAUGHAN (1970), VOGEL (1967 a, b), WEIS-FOGH (1973). An account of the mechanism of animal flight is also considered by LEYTON (1975) and more recently by ALEXANDER (1977). The butterflies and some other insects have improved performance of the wings in flapping flight; the mechanism deviates from that of conventional aerodynamics (WEIS-FOGH, 1973). In the present paper, a systematic study of the aerodynamic parameters and flight characteristics of the tawny coster, *Telchinia violae* (FABRICIUS) has been undertaken and the powers needed in some cases are calculated.

MATERIAL AND METHODS

The tawny coster, *Telchinia violae* (FABRICIUS) is one of the most common butterflies at Santiniketan, West Bengal, India and is frequently observed during March to middle of May. It has two pairs of wings coupled together during flight. Cell and disc of both wings are with black spots (WYNTER-BLYTH, 1957).

The body mass and the mass of the fore- and hindwings of each specimen were determined with the help of an electronic balance. The wing area was traced on a paper and measured by using a planimeter. The flight duration was recorded in an open place with a stop watch and subsequently, the speed was calculated. Reynold's number was calculated from the formula $R_e = u \rho l_c / \eta$, where u is the velocity of flier, ρ is the density of air, η is the coefficient of viscosity of air and l_c is the chord which is taken here as $\frac{1}{4}$th of the forewing length ($\simeq$head + thorax). The observed minimum and maximum values of wing beat frequency were 15 and 20 Hz respectively.

The circumference at the widest point of the body was determined to measure the diameter. The aerodynamic parameters namely, length of the wing span (tip to tip of the wings), fore- and hindwing lengths, breadths, areas, wing loading (g/cm^2), aspect ratio were determined. The power required in some cases are calculated.

The kinetic energy of wing movement is shown by strip analysis. The wings were divided into four strips of equal length and each strip mass was measured with an electronic balance. Total moment of inertia about the axis passing through the body can be calculated by adding the moment of inertia of each strip.

OBSERVATIONS AND RESULTS

Table 1 shows the basic aerodynamic parameters of fifteen butterflies (the tawny coster) under investigation. The heavy butterflies have greater forewing loadings whereas their hindwing loadings are not so high in comparison with the lighter ones. The average wing loading, in general is found to be greater for heavier butterflies. This loading is also higher as compared to other insects which suggests the relative aerodynamic inefficiency of this flier.

TABLE 1. Basic flight parameters of the tawny coster (n = 15).

Parameters	Range	Mean ± SD
1. Body mass (g)	0.044–0.096	0.061 ± 0.016
2. Forewing length (cm)	2.4 –2.8	2.50 ± 0.108
3. Hindwing length (cm)	1.6 –1.8	1.73 ± 0.075
4. Wing span (cm)	4.9 –5.8	5.41 ± 0.24
5. Forewing and hindwing breadth (cm)	1.15 –1.3	1.220 ± 0.046
6. Wing area (two forewings) cm^2	3.4 –4.88	3.916 ± 0.424
7. Wing area (two hindwings) cm^2	2.6 –3.6	3.036 ± 0.312
8. Forewing length/forewing breadth	2.077–2.167	2.120 ± 0.038
9. Hindwing length/hindwing breadth	1.333–1.50	1.42 ± 0.044
10. Average aspect ratio	1.708–1.834	1.77 ± 0.041
11. Forewing loading ($g/cm^2 \times 10^{-3}$)	0.737–0.943	0.860 ± 0.061
12. Hindwing loading ($g/cm^2 \times 10^{-3}$)	0.719–1.107	0.827 ± 0.110
13. Mass of two forewings ($g \times 10^{-3}$)	2.8 –4.8	3.477 ± 0.610
14. Mass of two hindwings ($g \times 10^{-3}$)	2.0 –3.2	2.6 ± 0.422
15. Body mass/ (wing span)^2 ($g/cm^2 \times 10^{-3}$)	1.67 –2.85	2.056 ± 0.39
16. Body mass/ (two forewing length)^2 ($g/cm^2 \times 10^{-3}$)	1.849–3.174	2.255 ± 0.429
17. Body mass/ (two hindwing length)^2 ($g/cm^2 \times 10^{-3}$)	4.166–7.035	5.039 ± 0.980

:0.39

If m = mass of the body and m_f, m_h are respectively the mass of the fore- and hindwings, it will be seen that $2\ m_f/m$ is the lowest for the highest body mass and highest for the lowest body mass. Again, it is observed that $m/2\ (m_f + m_h)$ varies from 7.1 to 12.42, $m/2\ m_f$ from 13.75 to 20.87 and $m/2m_h$ from 14.7 to 32.08. The butterflies have long wings and beat at low frequency. Since the wing beat frequency of the butterflies is observed to be below 100 Hz, they belong to the category of neurogenic fliers.

The aspect ratio is defined as the ratio of the wing length to wing breadth (NEVILLE, 1965). In bats and birds a good correlation exists between the aspect ratio and wing loading but here, in fact, no correlation seems to exist. Calculation shows that the values of mass/(wing span)^2 are also variable (0.00167-0.00285).

Moment of inertia

The variation of moments of inertia with strip number for two body masses are shown in Fig. 1. The nature of the curves shows that the butterfly wing represents more or less a flat surface (plate). The total moments of inertia of the fore- and hindwings are respectively 2.19×10^{-3} g cm^2 to 4.70×10^{-3} g cm^2 and 0.72×10^{-3} to 2.46×10^{-3} g cm^2. The effective moment of inertia (combined mass $\times$ distance^2) changes from 3.75×10^{-3} to 7.84×10^{-3} g cm^2.

The moment of inertia I, is important to calculate the inertial power which is a function of I and depends on other factors such as frequency n, maximum angle of swing of the wing across the joint. The mass of air in the boundary layer which has to be accelerated with the wings should also be considered. This will influence the moment of inertia of the wings (VOGEL, 1962).

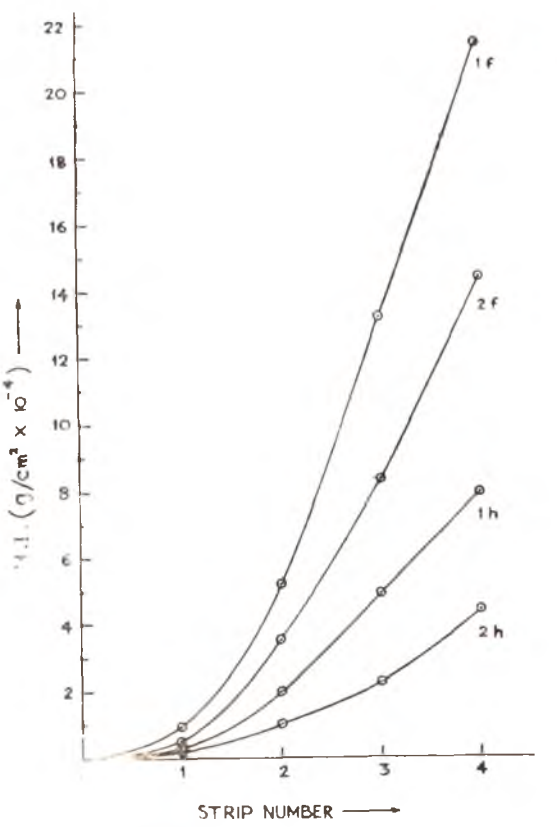


Fig. 1. Graph showing the relation between strip number and moment of inertia (M. I,), f for forewing, h for hindwing (1. Body mass = 0.096 g, forewing: length = 2.75 cm, mass = 0.0023 g; hindwing: length = 1.85 cm, mass = 0.0016 g. 2. Body mass = 0.048 g, forewing: length = 2,5cm, mass = 0.0016g; hindwing: length = 1.7cm, mass = 0.0011 g).

Other related observations

Difference in wing length of the fore- and hindwings lies between 0.8 and 1.0 cm. A typical aerodynamic characteristics of the tawny coster is that the maximum breadths of forewings and hindwings are found to be exactly the same and the average values of $l_f/l_h \simeq 1.5$ (l_f = forewing length, l_h = hindwing length).

The average value of diameter (of the body)/wing span of the tawny coster

is 0.09, a fairly typical value for this kind of butterfly. This is calculated for other butterflies also. Thus this value for the mottled emigrant, *Catopsila pyrantha* (LINNAEUS) is 0.08; for the plain tiger, *Danais chrysippus* (LINNAEUS) is 0.07; for the lime butterfly, *Papilio demoleus* (LINNAEUS) is 0.06.

The velocity of free horizontal flight (u) as observed in nature is variable from 1.74 m/s to 3.15 m/s. From the consideration of these speeds, it is found that the wings of this butterfly work at Reynolds' number ranging from about 6×10^4 to 11.2×10^4. In the case of the plain tiger, *Danais chrysippus* (LINNAEUS) u is found to be in the range of 2.077 m/s to 3.24 m/s and the value of R_e varies from 11.7×10^4 to 18.2×10^4. The range of R_e in the case of mottled emigrant, *Catopsila pyrantha* (LINNAEUS) is found to be 14.66×10^4 to 24.96×10^4. It is an important aerodynamic parameter since it is functionally related to the lift and drag. The minimum speed depends on the wing loading, mg/S_p, where g is the acceleration due to gravity ($= 9.81\ ms^{-2}$) and S_p is the wing area. Hindwing increases the wing loading and thereby can increase the forward speed.

Lift Coefficient

The lift coefficient, C_L can be calculated from the formula (ALEXANDER, 1977) and the average value of C_L is found to be 2.01. C_L for the plain tiger, *Danais chrysippus* (LINNAEUS) is also calculated and is found to be 1.98. These values tally with WEIS FOGH (1973).

Aerodynamic Power Requirement

The power P_a required to overcome drag on the two wings is given by ALEXANDER (1977) and taking $C_D = 0.4$, the average value of P_a/m is 2.11 W kg^{-1}

The average power, P_h needed for hovering as determined after ALEXANDER (1971) is $P_h/m = 3.3$ W kg^{-1}. This value is slightly lower than that of the plain tiger, *Danais chrysippus* (LINNAEUS). (The calculated value of P_h/m for the plain tiger is found to be 3.5 W kg^{-1}).

As m increases, P_h increases faster than the power available. P_{min} required to maintain a body of mass m stationary in air is given by LEYTON (1975).

$P_{min} = (m^2 g^3 / 2a\rho)^{1/2}$,

a = area swept out by the wings.

Therefore, $P_{min}/m \propto (m/a)^{1/2}$.

(Hovering insects beat each wing through about 1.0°).

If, however, m is too large, it is impossible for an animal to fly. The maximum weight for forward flight is higher than the maximum weight for hovering.

DISCUSSION

The aerodynamic parameters of the tawny coster give $l_h > b_h$, $l_f > 2b_f$ where l_h, b_h, l_f and b_f are respectively the hindwing length, hindwing breadth, forewing length and forewing breadth. The insects with longer and narrower wings give better performance of flight than those that have shorter and broader wings.

The total surface area of the wings determines the load which a butterfly can lift under given conditions. It has been observed that if an extra load, $\frac{1}{4}$th of the body weight is added to the forewings of the tawny coster, it is unable to fly. With the addition of further load, its tendency is to leap. Even if the total surface area is the same for two butterflies, the one with the higher aspect ratio can fly faster than the other

The performance of a butterfly depends on: (a) maximum lift coefficient, which will determine the landing speed for a butterfly of given wing loading; high maximum C_L will give a low landing speed (b) maximum lift (L_i)—drag (D) ratio, which gives the general efficiency of a butterfly, for carrying a large weight for a small thrust. The high values of L_i/D will enable the butterfly to glide far.

Large butterflies have high wing loading, the minimum gliding speeds for them are higher than for small ones and that they can glide faster, for similar sinking speeds The minimum gliding gradient is lower for them. For small values of the glide angle, the expression for the rate of descent or sinking speed u_s is given by LEYTON (1975).

When a tawny coster decends slowly, its wings remain flat and do not beat; the nature of descent follows a slanting path. When it flies from one flower to another, its wings may beat but the frequency is less. If it descends along a straight path from high altitude, its wings flap. They can change their wing areas with the help of hindwings which can increase the efficiency of flying. If the combined area is reduced, wing loading increases and thereby forward speed is increased for any given sinking speed and there is an optimum wing area of the adjusted (combined) wings for any given forward speed. They lose height less rapidly when gliding fast if the wing area is reduced i. e., hindwing is exactly below the forewing.

If the two hindwings are cut off at the fulcrum, it cannot go high up and moves almost parallel to the ground; it is then unable to fly at a stretch and after a few seconds it comes to the ground. The hindwing can increase the loading as well as the area.

If 1/4th of the total lengths of the forewings are cut at the ends and is allowed to fly, it tends to go upwards whereas if these are folded at 1/4th of the lengths (wing area decreases and mass loading increases), the tendency of this butterfly is to move gradually upwards to a certain height in a slanting way. The nature of flight is observed to be different in the two cases At the normal resting stage, the two wings cannot be distinguished. At the flying stage, the effective breadth of the wing is controlled by hindwing.

Acknowledgements:—The first author is indebted to the U G C (New Delhi) for financial support.

REFERENCES

ALEXANDER, R. McN. (1971) *Size and Shape.* Edward Arnold, 42–46.

ALEXANDER, R. McN. (1977) Flight, *in*: *Mechanics and Energetics of Animal Locomotion.* (ALEXANDER, R. McN. & G. GOLDSPINK eds.) Chapman and Hall, London. 249–278.

LEYTON, L. (1975) *Fluid Behaviour in Biological Systems.* Clarendon Press, Oxford, 66—79.

NEVILLE, A. C. (1965) Energy and economy in insect flight. *Sci. Progr.*, **53**, 203—219.

FENNYCUICK, C. J. (1975) Mechanics of flight, *in* : *Avian Biology.*, Academic Press, New York. **5**, 1—75.

TUCKER, V. A. & G. C. PARROTT (1970) Aerodynamics of gliding flight in a falcon and other birds. *J. exp. Biol.*, **52**, 345—367.

VAUGHAN, T. A. (1970) Flight patterns and aerodynamics, *in*: *Biology of Bats.* (WIMSATT W. B., ed.), Academic Press. New York. **1**, 195–216

VOGEL, S, (1962) A possible role of the boundary layer in insect flight. *Nature*, **193**, 1201—1202.

VOGEL, S. (1967 a) Flight in Drosophila. II. Variations in stroke parameters and wing contour. *J. exp. Biol.*, **46**, 383—392.

VOGEL, S. (1967 b) Flight in Drosophila. III. Aerodynamic characteristics of fly wings and wing models. *J. exp. Biol.*, **46**, 431–443.

WEIS-FOGH, T. (1973) Quick estimates of flight fitness in hovering animals, including novel mechanisms for lift production. *J. exp. Biol.*, **59**, 169–230.

WILSON, J. A. (1975) Sweeping flight and soaring by albatrosses. *Nature*, **257**, 307–308.

WYNTER BLYTH, M. A. (1957) *Butterflies of the Indian Region*. The Bombay Natural History Society, Bombay. First ed. 233–235.

Entomon, 1981, *Vol.* **6**, *No.* 4, *pp.* 317 *to* 323

STUDIES ON THE APHIDS (HOMOPTERA : APHIDIDAE) OF NAGALAND

S. K. RAHA & D. N. RAYCHAUDHURI

Entomology Laboratory, Department of Zoology, University of Calcutta,
35 Ballygunge Circular Road, Calcutta, India 700 019

(Received 28 June 1980)

The paper reports 59 species under 49 genera of aphids from Nagaland, of which one species is new to science, 57 are new records for the state and one is a new record for India.

(Key words: aphids-new species and new records)

More vigorous investigation on aphids in India has been started since 1950's. But with respect to the present area of survey the first report on the aphid fauna of the area was made by Ghosh *et al.* (1971). Following that a few reports, *viz.*, Raychaudhuri *et al.* (1977), Raha *et al.* (1977) appeared. As a result, 42 species distributed over 28 genera were known to occur in Nagaland. This paper further reports 59 species including one identified upto genus level under 49 genera distributed over 6 subfamilies. Of these one hormaphidine species is new to science, 57 are new records for the state and 1 is a new record for India. The paper also includes the description of new species *Neotuberaphis indica* and that of *Nipponaphis* sp. New record of aphid species from India has been denoted by * mark.

All the material are in the collection of the Aphid Research Unit, Entomology Laboratory, Department of Zoology, University of Calcutta.

A list of newly recorded aphid species together with their host plants is given below:

Aphid species	Host plant
Subfamily : Aphidinae	
Tribe : Aphidini	
1. *Aphis ruborum longisetosus* Basu	*Rubus ellipticus*
2. *Hyalopterous pruni* (Geoffroy)	*Prunus cerasus*
3. *Rhopalosiphum nymphaeae* (Linnaeus)	*Monochoria hastaefolia*
4. *Rhopalosiphum rufiabdominalis* (Sasaki)	*Dianthus* sp.
	Malva rotundifolia
5. *Toxoptera citricidus* (Kirkaldy)	*Citrus* sp.
6. *Toxoptera odinae* (van der Goot)	*Cassia siasmen*
	Mangifera indica

Aphid species	Host plant
Tribe : Macrosiphini	
7. *Amphorophora ampullata bengalensis* Hille Ris Lambers and Basu	Fern
8. *Aulacorthum nipponicum* (Essig & Kuwana)	*Tethonia tageteiodes*
9. *Brevicoryne brassicae* (Linnaeus)	*Brassica* sp.
10. *Capitophorus formosartemisiae* (Takahashi)	*Artemesia nepalensis*
	Artemesia vulgaris
	Chrysanthemum indicum
11. *Cryptomyzus taoi* Hille Ris Lambers	*Artemesia* sp.
12. *Cryptosiphum artemesiae* Buckton	*Artemesia vulgaris*
13. *Dactynotus sonchi* (Linnaeus)	*Sonchus* sp.
14. *Diphorodon cannabis* (Passerini)	*Cannabis sativa*
15. *Indomegoura indica* (van der Goot)	Unidentified
16. *Macrosiphoniella pseudoartemesiae* Shinji	*Artemesia* sp.
17. *Macrosiphum rosae* (Linnaeus)	*Rosa* sp.
18. *Micromyzus kalimpongensis* Basu	*Curcuma longa*
19. *Myzus siegesbeckieola* Strand	*Prunus cerasus*
20. *Pentalonia nigronervosa* Coquerel	*Colocasia* sp.
	Musa sp.
21. *Rhodobium porosum* (Sanderson)	*Rosa indica*
22. *Rhopalosiphontnus latysiphon* (Davidson)	Unidentified
23. *Sappaphis pyri* (Boyer de Fonscolombe)	*Pyrus malus*
24. *Semiaphis heraclei* (Takahashi)	Unidentified
25. *Sinomegoura citricola* (van der Goot)	*Smilax* sp.
26. *Subovatomyzus leucosceptri* Basu	*Colebrookia oppositifolia*
	Leucosceptrum cannum
27. *Vesiculaphis kalimpongensis* Ghosh, Basu and Raychaudhuri	*Artemsia* sp.
Subfamily : Callipterinae	
28. *Clethrobius dryobius* Chakrabarti and Raychaudhuri	*Prunus cerasus*
29. *Neobetulaphis pusilla* Basu	*Betula* sp.
30. *Tinocallis himalayensis* Ghosh, Ghosh and Raychaudhuri	Unidentified
31. *Tuberculaius nervatus* Chakrabarti and Raychaudhuri	*Quercus* sp.
Subfamily : Greenideinae	
Tribe : Cervaphidmi	
32. *Cervaphis rappardi indica* Basu	*Cajanus cajan*
33. *Schoutedenia lutea* (van der Goot)	*Phyllanthus reticulatus*
Tribe : Greenideini	
34. *Eutrichosiphum pasaniae pseudopasaniae* Szelegiewicz	*Quercus* sp.
	Schima wallichi

Aphids species	Host plant
35. *Eutrichosiphum pyri* Chakrabarti, Ghosh and Raychaudhuri	Unidentified
36. *Eutrichosiphum taoi* Ghosh, Basu and Raychaudhuri	*Quercus* sp.
37. *Eutrichosiphum (Neoparatrichosiphum) flavum* (Takahashi)	*Quercus* sp
38. *Eutrichosiphum (Neoparatrichosiphum) raychaudhurii* (Ghosh)	*Alnus nepalensis*
39. *Greenidea ficicola* Takahashi	*Ficus* sp. *Ipomoea* sp.
40. *Greenidea longirostris* Basu	*Schima wallichi*
41. *Greenidae (Trichosiphum) anonae* (Perdange)	*Symplocos thisefolia*
42. *Holotrichosiphum russellae* Ghosh, Ghosh and Raychaudhuri	*Quercus* sp.
43. *Mollitrichosiphum (Metatrichosiphon) alni* Ghosh, Ghosh and Raychaudhuri	*Alnus nepalensis*
44. *Mollitrichosiphum (Metatrichosiphon) nandii* Basu	*Clerodendron serratum*
Subfamily : Hormaphidinae	
45. *Cerataphis variabilis* Hille Ris Lambers	*Areca catechu*
46. *Ceratoglyphina bambusae bengalensis* Ghosh	*Bambusa* sp.
47. *Ceratovacuna lanigera* Zehntner	*Bambusa arundinaceae* *Saccharum officinarum*
48. *Neotuberaphis indica*, sp. nov.	*Eugenia* sp.
49. *Kurisakia indica* Basu	*Litsea polyantha*
50. *Nipponaphis* sp.	*Litsea polyantha*
51. *Paraoregma alexanderi* (Takahashi)	*Bambusa* sp.
52. *Pseudoastegopteryx himalayensis* Ghosh, Pal and Raychaudhuri	*Bambusa arunadinaceae*
53. *Pseudoregma bucktoni* Ghosh, Pal and Raychaudhuri	*Bambusa* sp.
Subfamily : Lachninae	
54. *Cinara atrotibialis* David and Rajasingh	*Pinus* sp.
55. *Lachnus tropicalis* (van der Goot)	*Quercus* sp.
56. *Nippolachnus piri* Matsumura	*Prunus communis*
Subfamily : Pemphiginae	
57. *Geoica lucifaga* (Zehntner)	*Oryza sativa*
58. *Tetraneura basui* Hille Ris Lambers	*Eleusine corocana* *Eragrostis amabilis*
59. *Tetraneura radicicola/yezoensis* group	Uuidentified grass

1. Neotuberaphis indica, sp. nov.

Apterous viviparous female: Body oval brown, about 1.30 — 1.50 mm long, with a row of indistinct round to oval wax-plates along the margin excepting the head. Head (Fig 1A) brown, fused with prothorax, 2-tubercles on dorsum of head, each bearing a stout spine-like hair; dorsal cephalic hairs short and with acuminate apices, longest of these about 0.60—0.70 × b. d. III. Antennae (Fig. 1B) 5-segmented, brown, about 0.32—0.35 × body; segment I broader than long, segment II longer than segment I and each with 2 long hairs; flagellum brown, with spinular imbrications; flagellar hairs short and with acuminate apices, sparsely distributed, longest hair on segment III about 0.50—0.70 × b. d. III; p. t. about 0.28—0.33 × base of last segment; secondary rhinaria absent; primary rhinaria ciliated. Eyes 3-faceted. Rostrum reaches just beyond midcoxae; u. r. s. (Fig. 1C) short and blunt, about 0.66—0.72 × h. t. 2 and without secondary hair Midthoracic furca with separate arms. Abdomen pale brown with segments 1—6 fused and segments 7 and 8 distinct; indistinct wax-pores on all abdominal segments excepting on segment 8; dorsal hairs similar to cephalic hairs, longest hair on tergites 1, 7 and 8 about 0.55—0.70 × 0.60—0.75 × and 0.60—0.75 × b. d. III respectively. Siphunculi poriform; cauda transversely oval and bears 2 long and stout hairs. Legs brown, short covered with a few long and stout hairs; femora and tibiae smooth; trochanter completely fused with femora; second segment of tarsi with faint imbrications and with long dorsoapical hairs having funnel shaped apices; empodial hairs longer than the claw and with knobbed apices; F. T. C. 4,4,2 or 4,4,4.

Alate viviparous female: Body about 1.35—1.47 mm long and about 0.67—0.79 mm as its maximum width. Head dark brown, with a distinct median suture and reduced tubercles on dorsum; dorsal cephalic hairs short and with acuminate apices, about 0.41 — 0.54 × b. d. III. Antennae (Fig. 2A) 5-segmented, about 0.50—0.55 × body; flagellum with distinct spinular imbrications; subannular secondary rhinaria over entire flagellum; flagellar hairs sparse, short aud with acuminate apices, longest one on segment III about 0.41—0.45 × b. d. III. Ultimate rostral segment about 0.68—0.73 × h. t. 2 and without secondary hair. Abdomen pale brown; dorsal hairs short and with acuminate apices, longest one on segments 1, 7 and 8 about 0.40 — 0.50 × 0.40 — 0.58 and 0.42—0.50 × b. d. III. Siphunculi poriform. Cauda transversely oval and bears 2 stout hairs. Media of forewing once-branched (Fig. 2B) and hindwing with 2 oblique veins (Fig. 2c). Veins dark.

Measurements of one aptera (holotype) in mm: Length of body 1.47, width 1.02; antenna 0.49, segments III : IV :V 0.18 :0.07: (0.09+0.03); u. r. s. 0.06; h. t. 2 0.09.

Measurements of one alata in mm: Length of body 1.47, width 1.02; antenna 0.49. segments III:IV :V 0.34:0.12: (0.15+0.03), u. r. s. 0.05; h. t. 2 0.08.

Holotype: Apterous viviparous ♀, INDIA : NAGALAND : Ghaspani, 13. v 1978 from *Eugenis* sp , Coll. S. RAHA, **Paratypes:** many apterous viviparous ♀♀, alate viviparous ♀♀ and nymphs. collection data same as for holotype.

Note: The specimens, in life, look dark brown and were collected from the leaves causing peculiar marginal folds into which they live with white waxy covering. The infestation on the host was heavy.

Remark: This species belongs to the genus *Neotuberaphis* (Ms. name) erected by Pal and Raychaudhuri from material

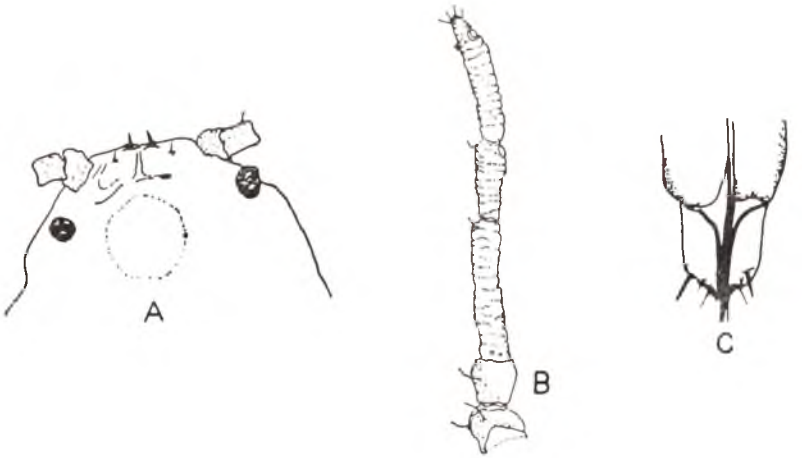


Fig. 1. *Neotuberaphis indica*, sp. nov. : Apterous viviparous female.
A. Dorsum of head B. Antenna C. Ultimate rostral segment.

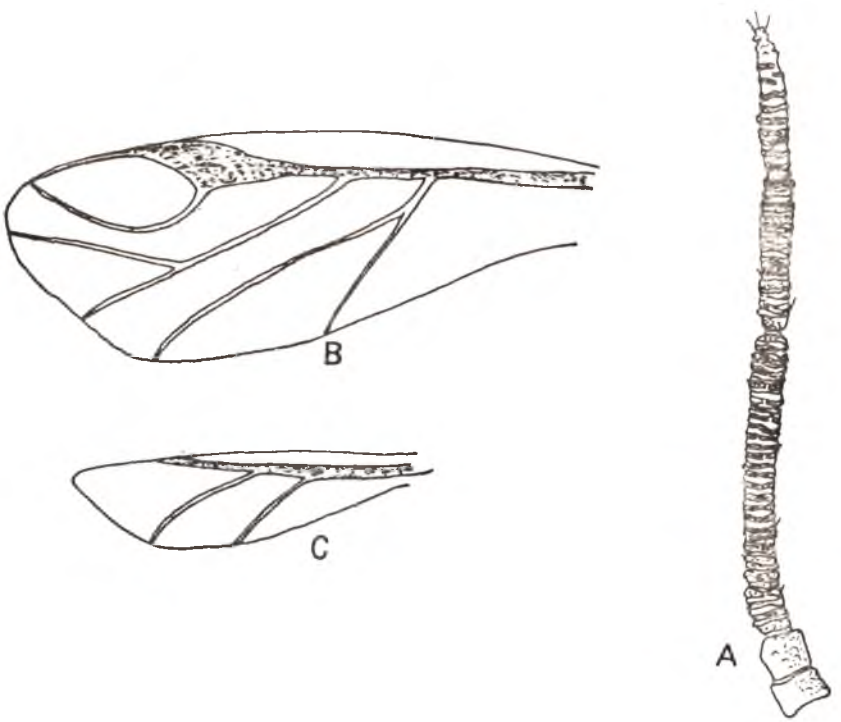


Fig. 2. *Neotuberaphis indica*, sp. nov. : Alate viviparous female.
A. Antenna B. Fore-wing C. Hindwing.

Nipponaphis sp. Apterous viviparous female.

collected in North-East India. This genus in having the spiny hair bearing tubercles on the head and one row of wax-plates on the margin of abdomen in apterous viviparous females comes close to *Tuberaphis* Takahashi (1933), but differs from the latter by the presence of cribriform wax-pores all over the body including the head and the absence of rugosity on the abdominal dorsum of the same morph.

A new species is now described under the genus and with this new species the genus *Neotuberaphis* (Ms. name) Pal and Raychadhuri is now known to contain 2 species, *viz*, *bengalensis* Ms. name Pal and Raychaudhuri) and *indica* from India

The key below would help to differentiate this new species from *bengalensis* (Ms. name) Pal and Raychaudhuri.

2 Nipponaphis sp.

Apterous viviparous female: Fig 3) Body semioval, brown, about 1.23—1.53 mm long. Antennae short, slender, 4-segmented, distance between antennal joints of head nearly as long as the antenna. Rostrum with segments 4 and 5 distinct; u. r. s. about 1,50—1.62 × h. t. 2. Prosoma defined from fused part of abdomen (2—7), densely covered with circular pastules, some of such pastules on margin sharply pointed at tip; dorsal hairs on prosoma long and fine usually 2.70—3.0 times as long as the basal diameter of antennal segment III. Dorsum of fused abdominal segments (2—7) covered with circular pastules; segments (2—7) with 6 pairs of long and stout submarginal hairs, segment 8 with long hairs. Siphunculi pore-like but easily discernable. Cauda dark, with about 6—7 hairs Subanal plate bilobed. Legs short, pale; tarsi two segmented with claws; a pair of dorsoapical hairs on second tarsal segments with swollen or funnel shaped apices. F. T. C. 3, 3, 2.

Measurements of one aptera in mm: Length of body 1.23, width 1.08; antenna 0.28, segments I:II:III:IV 0.03:0.03:0.14: 0.08; u. r. s. 0.09; h. t. 2 0.10; siphuncular pore 0.02; length of cauda 0.03; width 0.0[illegible].

Collection data: Many apterous viviparous ♀♀, and nymphs. INDIA : NAGALAND: Ghaspani, 6. xi. 1977, from *Litsea polyantha*, coll. S. RAHA.

Note: Brown apterae and nymphs were found along the stem.

Remark: Ghosh and Raychaudhuri (1973) mentioned that presence of posteromesial setas 7th abdominal tergite as one of the characters of the genus *Nipponaphis*. The present material lacks posteromesial setae on 7th abdominal tergite but otherwise it is a member of the genus *Nipponaphis*. So it is tentatively included in *Nipponaphis* and no species status has been given to it for the present.

KEY TO THE SPECIES

Apterous viviparous female:

Dorsal body hairs long, longest hair on segments 1,7 and 8 about 1.35—1,45×, 2.00—2.10 × and 1.90—2.40×b.d,III respectively; u. r s. about 0.85—0.95 × h. t. 2 and bears 2 long secondary hairs . . . . . *bengalensis* (Ms. name) Pal and Raychaudhuri

Dorsal body hairs short, longest hair on segments, 7 and 8 about 0.55—0.70 ×, 0.50—0.75 × and 0.60—0.75 × b.d. III respectively; u. r. s. about 0.66—0.72 × h. t. 2 and without secondary hair. . . . . *indica*, sp. nov.

Acknowledgement:—The authors are thankful to the University Grants Commission, New Delhi for partly financing the project for working on the aphids of Manipur and Nagaland.

REFERENCES

GHOSH, A. K., H. BANERJEE & D. N. RAYCHAUDHURI (1971) Aphid species collected from Manipur and Nagaland. *Gavesna*, 3 (4); 60-61

GHOSH, A. K. & D. N. RAYCHAUDHURI (1973) Studies on the aphids (Homoptera : Aphididae) from Eastern India. XV. A study of *Nipponaphis* Pergande and related genera with description of a new genus and eight new species from eastern India. *Kontyu*, **41** (2) 148—165 and **41** (4), 477—496.

RAHA, S. K., T. K. SINGH, D. RAYCHAUDHURI & D. N. RAYCHAUDHURI (1977) New records of aphids (Homoptera : Aphididae) from Manipur and Nagaland. *Sci. Cult.*, **43**, 452—453.

RAYCHAUDHURI, D. N., S. K. RAHA & D. RAYCHAUDHURI (1977) Three new species of aphids (Homoptera : Aphididae) from Manipur and Nagaland. *Entomon*, **2** (1), 71—75.

TAKAHASHI, R. (1933) Three interesting aphids from the Far-east. *Stylops*, **2** (2), 27—30.

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 325 *to* 327

NEW RECORDS OF TETRANYCHOID MITES OF ORNAMENTAL AND MEDICINAL PLANTS AND THEIR HOSTS FROM THE PUNJAB STATE

G. L. SADANA, S. C. CHHABRA & NEELAM KUMARI

Department of Zoology, Punjab Agricultural University, Ludhiana, India

(Received 29 November 1980)

Fifteen species of Tetranychoid mites of ornamental and medicinal plants are reported from the Punjab State on new hosts. *Bakerina aculus* Chaudhri and *Tenuipalpus pernicis* Chaudhri, Akbar and Rasool are recorded for the first time from India and Punjab respectively. *Brevipalpus rugulosus* Chaudhri, Akbar and Rasool *B. karachiensis* Chaudhri, Akbar and Rasool, *Tenuipalpus punicae* Pritchard and Baker and *Schizotetranychus undulatus* (Beer and Lang) are recorded for the first time on ornamental and medicinal plants.
(*Key words:* new records, new hosts, mites)

INTRODUCTION

The tetranychoid mites are of considerable economic importance as they feed exclusively on plants. Our knowledge about such mites of the Punjab state is rather incomplete particularly concerning those which infest ornamental and medicinal plants. Prior to this study, only 14 species of mites were known to infest these plant categories in the Punjab (Gupta *et al*, 1971; Gupta, 1976; Sadana & Kanta 1972; Sadana & Joshi, 1976; Sadana & Chhabra, 1974, 1980a, b, c, d and Maninder & Ghai, 1978). During extensive surveys of the tetranychoid mites infesting ornamental and medicinal plants in the Punjab State, we have recorded fifteen species of mites on new host plants. Of these, *Bakerina aculus* Chaudhri *Tenuipalpus pernicis* Chaudhri, Akbar and Rasool, are recorded for the first time from India and Punjab respectively. *Brevipaplus rugulosus* Chaudhri, Akbar and Rasool, *B. karachiensis* Chaudhri, Akbar and Rasool *Tenuipalpus punicae* Pritchard & Baker and *Schizotetranychus undulatus* (Beer and Lang) are recorded for the first time on ornamental and medicinal plants although these are known to occur on other plants in the state. The mite species encountered on ornamental and medicinal plants during the surveys are embodied systematically together with their new hosts hereunder.

Family Tetranychidae

1. **Aponychus sulcatus** Chaudhri
   Host : ex *Sachharum spontaneum.*

2. **Eutetranychus orientalis** (Klein)
   Hosts: ex *Jasminus sambac*, *Zinnia* sp., *Tagetes erecta*, *Tabernaemontana divaricata*, *Callistemon lanceolatus*, *Passiflora* sp., *Hibiscus rosa-sinensis*, *Datura alba*, *Ficus religiosa*, *Euphorbia pulcherima*, *Plumeria acutifolia* and *Carthamus roseus.*

3. **Schizotetranychus undulatus** (Beer and Lang)
   Hosts : ex *Acacia arabica* and *Jasminum grandiflorum*

4. **Bakerina aculus** Chaudhri
   Hosts: ex *Thuja orientalis.*

5. Tetranychus cinnabarinus (Boisduval)
Hosts : ex *Ocimum sanctum*, *Arctotis* sp., *Jasminus sambac* and *Canna indica*.

Family *Tenuipalpidae*

6. Aegyptobia nummulus Chaudhri
Host: ex *Cupressus* sp.

7. Brevipalpus californicus Banks
Hosts : ex *Tagetes erecta*, *Dracaena cinnabari*, *Clerodendron splendens*, *Lawsonia inermis*, *Ocimum sanctum* and *Jasminum grandiflorum*

8. Brevipalpus obovatus Donnadieu
Hosts : ex *Jasminus sambac*, *Callistemon lanceolatus*, *Plumeria acutifolia*, *Solidago canadensis*, *Celosia cristata*, *Lantana camara* var. *aculeata*, *Datura alba*, *Ocimum sanctum*, *Ricinus communis*, *Delphinium ejacis*, *Coleus* sp , *Helianthus annus*, *Chrysanthemum* sp., *Gomphrena globosa*, *Zinnia* sp., *Michelia champaca*, *Citrus limon*, *Dahlia* sp., *Ocimum basilicum* and *Carthamus roseus*.

9. Brevipalpus phoenicis (Geijskes)
Hosts: ex *Thevetia peruviana*, *Campsis grandiflora*, *Polyalthia longifolia*, *Anthocephalus cadumba*, *Chrysanthemum* sp., *Jasminus sambac*, *Malvaviscus conzatti*, *Clerodendron inermis*, *Bauhinia variegata*, *Hibiscus rosa-sinensis*, *Plumeria acutifolia*, *Zinnia* sp., *Cosmos* sp., *Datura alba*, *Cymbopogon* sp., *Pothos scandens* and *Solanum nigrum*.

10. Brevipalpus karachiensis Chaudhri, Akbar and Rasool
Hosts: ex *Zinnia* sp., *Callistemon lanceolatus*, *Anthocephalus cadumba* and *Lagerstroemia indica*,

11. Brevipalpus rugulosus Chaudhri, Akbar and Rasool.
Hosts : ex *Canna indica*, *Zinnia* sp. *Cannabis sativus*. *Polyalthia longifolia*, *Tabernaemontana divaricata*, *Tagetes erecta*, *Acacia arabica*, *Solidago canadensis*, *Helianthus annus*, *Solanum nigrum*, *Campsis grandiflora*, *Acalypha wilkesiana*, *Celosia cristata*, *Citrus limon*, *Cosmos* sp., *Rosa indica*, *Plumeria acutifolia*, *Ricinus communis*, *Vallaris solanacea* and *Datura alba*.

12. Tenuipalpus mustus Chaudhri
Host: ex *Melia azedarch*.

13. Tenuipalpus punicae Pritchard & Baker
Host: ex *Tecoma stans*.

14. Tenuipalpus pernicis Chaudhri, Akbar& Rasool
Host: ax *Calotropis procera*.

15. Tenuipalpus ludhianaensis Sadana & Chhabra.
Host : ex *Melia azedarch*.

Acknowledgements:—The authors are thankful to Dr. S. S. Guraya, Professor and, Head Department of Zoology, Punjab Agricultural University, Ludhiana, for laboratory facilities and to I C A R for financing the scheme to carry out the taxonomic studies on Tetranychoid mites.

REFERENCES

Gupta, S. K. (1976) Contribution to our knowledge of Tetranychid mites (Acarina) with description of three new species from India. *Oriental Ins.*, **10** (3), 327—351.

Gupta, S. K., A. S. Sidhu, M. S. Dhooria & G. Singh (1971) Preliminary note on the phytophagous and predatory mite fauna of the Punjab and Himachal Pradesh. *Sci. Cult.*, **37**, 296—299.

Maninder & S. Ghai (1978) A new species of *Colopalpus* (Acarina : Tenuipalpidae) from India. *Oriental Ins.*, **12** (1), 111—113.

Sadana, G. L. & V. Kanta (1972) Studies on the host range of the mite *Eutetranychus orientalis* (Klein). *Sci. Cult.*, **38** (12), 528-533.

Sadana, G. L. & R. Joshi (1976) Host range of the mite *Brevipalpus californicus* (Banks) infesting citrus. *Sci. Cult.*, **42** (2), 106.

Sadana, G. L. & S. C. Chhabra (1974) New records of hosts and predators of the phytophagous mite, *Oligonychus mangiferus* (Rahman & Sapra). *Sci. Cult.*, **40** (8), 362-363.

SADANA, G. L. S. C. CHHABRA (1980a) Two new species of the genus *Tenuipalpus* DONNADIEU and distributional records of others from India. *Entomon*, **5** (2), 151—155.

SADANA G. L. & S. C. CHHABRA (1980b) Distribution and new records of Tetranychid mites of the Punjab. *J. Adv. Zool.*, **1** (2), 104-109.

SADANA, G. L. & S. C. CHHABRA (1980c) An addition to the Tetranichoid mite fauna of the Punjab, India. *Sci. Cult.*, **46** (10), 369-370.

SADANA, G, L. & S. C. CHHABRA (1980d) New records of phytophagous mites (Acarina : Tetranychoidea) from India. *Sci. Cult.*, **46** (11), 399—401.

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 329 *to* 333

ECLOSION RHYTHM AND ITS ENTRAINMENT BY PHOTOPERIODISM IN *PYRAUSTA (HAPALIA) MACHAERALIS* WALKER (LEPIDOPTERA : PYRALIDAE)

B. GOPAKUMAR & V. K. K. PRABHU

Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695 581

(Received 15 April 1981)

Pupal eclosion in *Pyrausta (Hapalia) machaeralis* starts usually from about one h after the beginning of the scotophase and ceases one h after midnight. Peak period of adult emergence is between 9 PM and 11 PM. There is an early preponderance of females emerging from a brood which probably prevents to a certain extent inbreeding. Pupae subjected to constant light condition show the same rhythm of eclosion However, eclosion is arhythmic when animals are subjected to constant light throguhout their life from larval emergence from eggs to adult emergence. Adults then emerge at all times during the day and night without showing any peak period. Thus the eclosion rhythm in this animal is entrained by the daily photoperiodism when the animals are subjected to it from early larval stages.

(*Key words:* eclosion rhythm, entrainment, photoperiodism, *Purausta (Hapalia) machaeralis*)

INTRODUCTION

Many developmental events occurring once in the life of insects, are controlled by circadian oscillations so that a particular event occurs at a definite time. Imaginal ecdysis, most apparent among these has been observed to follow a circadian rhythm in many insects, correlated with the locomotor activity rhythm and reproductive behavioural patterns of that species. Among the Lepideptera, *Archips negundanus* emerges only during night (PARKER & MAYOR, 1972) and the corn earworm *Heliothis zea* emerges between 7 P M and 11 P M (BECK, 1968) though the carpenterworm moth, *Prionoxystus robiniae* has a peak period of emergence around midday (SOLOMON & NEEL, 1972). The dragonfly *Tetragoneuria cynosura* emerges before 9 A M; a number of chironomids emerge between sunset and midnight and dipterans like *Drosophila* spp. and *Scatophaga stercoraria* have morning maxima of emergence (BECK, 1968). On the other hand emergence is an arhythmic event in *Aedes aegypti* (SAUNDERS, 1979). Some endogenous rhythms like feeding activity, locomotor activity etc. freeruns in the absence of environmental cues. But an entrainment by light in the pattern of eclosion takes place when the photoperiodic 'zeitgeber' is included from the very beginning of development. The present paper deals with the circadian rhythm of eclosion in *Pyrausta machaeralis* and its enterainment by photoperiodism.

MATERIAL AND METHODS

P. machaeralis is a notorious teak leaf skeletonizer causing damage in teak plantations. Original stock of the laboratory colony of the insect was from Kulathupuzha plantations 62km away from Trivandrum city. Larvae were reared in polythene basins on teak leaves. Pupae formed were taken out and kept in clean specimen

bottles. Moths emerged from them in 5—6 days, which were transferred to glass chimneys. The rearing vessels were covered with fine mesh cloth to prevent animals' escape. Not more than two pairs of moths were kept in one chimney. Cotton swabs soaked in 10% sugar solution were kept in chimneys. The moths sucked sugar solution from the swabs. Eggs laid each day were kept isolated from the others. Larvae which normally emerged from the eggs by three days, were transferred to basins. Rearing was carried out under laboratory conditions of temperature (23°—32°C) humidity (70%—94%) and light dark cycles (approximately 12:12). Insects for experiments were taken from this colony.

Experiment 1. Pupal behaviour and eclosion:

The pupal behaviour and eclosion rhythm were studied under laboratory conditions during June, September and December 1979. Pupae formed each day were collected from the colony on five consecutive days. Each day's collection was divided into groups of 10 each and kept in chimneys for adults to emerge. The adults were counted and removed at 1 h interval. A total of 451 pupae were studied during three months. Mode of dehiscence of pupal skin at adult emergence was also observed.

Experiment 2. Influence of sex on the emergence pattern:

This experiment was designed to study the influence of sex on the pattern of adult emergence in the laboratory colony. For this, four pairs of moths were selected from the colony and the progeny of each pair were reared in isolation. Sex of the adults emerging from these isolated colonies was noted every day in the morning.

Experiment 3. Effect of light on the eclosion rhythm:

The third series of experiments were designed to study the effects of light on the eclosion rhythm. Eclosion was studied (a) subjecting pupae during the entire pupal period to light (LL) provided by two 40W fluorescent tubes from a height of seven feet during night, and by day light during day. For this, pupae, in seven groups of ten each, were kept in glass chimneys, opening of which was covered with perforated polythene paper permitting free access to air. Eclosion was recorded at 1 h interval. Finally (b) larvae from the time of hatching out from the eggs, as well as their pupae were subjected to continuous light (LL) as before till the adults emerged. Soon after larvae hatched from eggs 10 larvae were transferred to each teak leaf placed inside the chimneys. Teak leaves were changed every day. From late 3rd instar onwards when the larvae were voracious, teak leaves were provided twice daily. Adult emergence was recorded at 1 h interval as previously.

OBSERVATIONS

Pupal behaviour and eclosion

Newly formed pupae were greenish white and delicate, enclosed in a translucent cocoon spun by the larvae between two folds of teak leaf. The cocoon is oval in outline and bears 14—16 small openings around its rim. It is not fastened to the leaf at its anterior end. Tanning takes place gradually. Pupae become yellowish green within 2 h of their formation and subsequently become brownish. On the day of eclosion they appear reddish brown. Pupae remain quiescent, but if disturbed now they many react by twisting the abdominal segments. When they are about to eclose they are slightly more active. Fixing their posterior tips with cremastral spines they rotate their bodies by twisting the abdominal segments. The pupal case ultimately splits along the epicranial suture and along the suture between the pronotum and the occiput. Head and part of the thoracic region come out through the slit first. About two minutes later the whole body is liberated from the pupal case by shaking the body from side to side. Quickly the newly emerged adult crawls a few feet and pauses for a minute. Then it begins to expand its wings which are kept folded till then and which extend only upto three fourths of its abdoman. Fully expanded wings are kept vertical for drying. They assume normal posture after about six minutes.

Normal eclosion rhythm

The data is represented in Table 1. It may be seen that adult emergence starts from about one hour after the beginning of scotophase and ceases one hour after midnight. Peak period of emergence is between 9 P M and 11 P M However a small percentage continues to emerge till early morning and about 5% of the adults emerge during photophase. In the heterogeneous population both sexes have the same rhythm of eclosion, 85% of males and 90% of females emerge during the dark. There is a slight change in the peak period of emergence during the different months under observation.

There is an early preponderance of females emerging from the four broods as seen in Table 2. This early preponderance of female emergence in the emergence rhythm narrows down during the successive days and subsequently a male preponderance is manifested among the brood. The mean probability of obtaining a female adult in the successive days of emergence drops from 0.9407 to 0.000 from the first day to the seventh day of emergence (Table 2). Interestingly, the mean probability levels show a sudden drop from 0.9407 to 0.5558 during the first two days of emergence and then onwards it decreases gradually. By analysis

TABLE 1. Eclosion rhythm of *Pyrausta* (*Hapalia*) *machaeralis* emerging under normal laboratory conditions of LD 12:12 (% of adult emerging, corrected to the nearest whole number; data pooled from different broods; numerator represents males; denominator represents females).

	H of day → / Month ↓	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11
Temp 26–29°C	June RH 90–98%	0/0	0/0	0/0	0/0	0/1	1/1	0/1	6/5	6/6	11/8	8/9	6/8	3/2	1/2	1/1	1/0	1/1	2/1	0/2	2/0	0/0	0/0	0/0	0/0
Temp 25–29°C	September RH 73–80%	0/0	0/0	0/0	0/0	1/1	0/0	0/1	2/4	6/7	9/9	9/7	8/10	7/6	4/2	1/0	1/0	0/1	0/1	0/0	0/0	0/0	0/0	0/0	0/0
Temp 23–29°C	December RH 70–85%	0/0	0/0	0/0	0/0	0/1	1/1	1/0	0/0	0/3	5/3	12/5	9/12	0/9	3/3	5/5	5/3	1/0	0/1	1/1	0/0	0/0	0/0	0/0	0/0

TABLE 2. Mean probability level of obtaining a female adult in the succeeding days of emergence from broods of 4 pairs of moths.

Day	Mean probability level	Coefficient variation
Ist ..	0.9407	7.893
2 ..	0.5558	24.411
3 ..	0.5101	16.23
4 ..	0.4430	21.94
5 ..	0.3549	54.96
6 ..	0.0682	—
7 ..	0.0000	—

pit = a + b Ti where pit is the probability of obtaining a female adult in t^{th} day of the i^{th} pair (i = 1 to 4, t = 1 to 7) and Ti is the day of emergence.
p i t = 0.94478−0.13495**T (r = −0.96937)**. **Significant at 0.01 probability level.

TABLE 3. Eclosion rhythm of *Pyrausta (Hapalia) machaeralis* under experimental conditions (% of adults emerging, corrected to the nearest whole number; data pooled from different broods).

Time of eclosion, h ⟶	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11
Pupae alone under LL; other stages under LD 12:12	0	0	0	0	0	0	4	12	15	22	24	15	6	3	0	0	0	0	0	0	0	0	0	0
All stages under LL	4	2	4	7	4	4	4	2	2	7	4	4	0	7	7	0	2	2	7	4	4	7	4	4

of the probability levels by a simple linear regression equation of the form given in the table, the value of the correlation coefficient is found to be negative and statistically significant at 0.01 probability level.

Pupae subjected to constant light (LL)

Pupae subjected to LL condition show the same rhythm of eclosion (Table 3). Peak period is still between 8 PM and 11 PM. The pupae do not entrain the shift in the photoperiod from LD to LL.

Animals subjected to constant light (LL) throughtout larval and pupal periods

Eclosion is arhythmic when animals are subjected to constant light throughout their life from larval emergence from eggs to adult emergence. Adults emerge at all times during day and night without showing any peak period (Table 3).

DISCUSSION

The present studies show that *Pyrausta machaeralis* resembles the pyralid moth *Dioryctria abietella* (FATZINGER & ASHER, 1971) with regard to the mode of eclosion from the pupae. In *P. machaeralis* males and females have the same maxima of emergence as in the lepidopterans *Halisidota argentata* and *Nepytia phantasmaria* (EDWARDS, 1964), although in *Pyrausta machaeralis* the present studies show that there is an early preponderance of females emerging from a brood. Slight deviations in the peak period of emergence during the different months under observation is apparently due to small changes of natural photoperiodic conditions. In the carpenterworm moth *Prionoxystus robiniae* males and females have different maxima of daily emergence, the peak period in males being 5—6 h earlier than that of females (SOLOMON & NEEL, 1972). In these animals the males attain sexual maturity in 5—6 h and the females within one hour after emergence (SOLOMON & NEEL, 1973). Thus their dual rhythm correlates well with their mating habits. Observations on the mating behaviour of *P. machaeralis* (unpublished observations) do not show any such correlation between earlier emergence of females and mating activities because newly emerged females do not mate until the third night after adult emergence. However, the early preponderance of female emergence from a brood apparently due to a shorter developmental period may prevent inbreeding in at least par of the population. Other significance, if any, of this difference between the sexes in the emergence pattern, on the biology of this animal is not known. Sensitivity to environmental cues vary markedly during

different stages of development of an insect. The flesh fly *Sarcophaga argyrostoma* show little sensitivity to light during pupal period and do not entrain a shift in the photoperiod (SAUNDERS, 1976). Its responsive period is restricted to larval instars. The early morning maxima of emergence of the screw-worm fly *Cochliomyia hominivorax* under LD 12:12 can be shifted to late afternoon when the photoperiodic regimen to which the larvae and pupae are subjected to is changed to LD 4:20. However the entrained rhythm is unaltered by photoperiodic shift in the pupal period alone (HIGHTOWER *et al.*, 1971). Observations on the entrainment by light on the eclosion behaviour in *P. machaeralis* thus appears to be comparable to those on the other insects reported above.

Acknowledgements: The authors are thankful to the UGC and INSA for grants, to Mr. C. RADHAKRISHNAN for statistical help, to Dr. N. R. PRABHOO for constructive criticisms, and to Prof. K. M. ALEXANDER for facilities afforded.

REFERENCES

BECK, S. D. (1968) Photoperiodism and adult emergence and swarming, *in: Insect Photoperiodism.* Academic Press, 288 pp.

EDWARDS, D, K. (1964) Activity rhythms of lepidopterous defoliators. II. *Halisidota argentata* PACK (Arctiidae) and *Nepytia phantasmaria* STKR (Geometridae). *Can. J. Zool.*, **42**, 939–958.

FATZINGER, C. W. & W. C. ASHER (1971) Observations on the pupation and emergence behaviour of *Dioryctria abietella* (Lepidoptera: Pyralidae (Phycitinae). *Ann. ent. Soc. Amer.*, **64** (2), 413—418.

HIGHTOWER, B. G., G. E. SPATES, Jr. & A. H. BAUMHOVER (1971) Emergence rhythms of adult screw-worms. *J. econ. Ent*, **64**, 1474—1477.

PARKER, D. L. & M. W. MAYOR (1972) Biology of a leafroller *Archips negundanus* in Utah (Lepidoptera : Tortricidae). *Ann. ent. Soc. Amer.*, **65** (6), 1415—1418.

SAUNDERS, D. S. (1976) The ciracadian eclosion rhythm in *Sarcophaga argyrostoma*: Some comparisons with the photoperiodic clock. *J. Comp. Physiol.*, **110**, 111—133.

SAUNDERS, D. S. (1979) *Insect Clocks - Circadian Rhythms of Activity in Populations of Insects.* Pergamon Press, 279 pp.

SOLOMON, J. D. & W. W. NEEL (1972) Emergence behaviour and rhythms in the carpenterworm moth *Prionoxystus robiniae. Ann. ent. Soc. Amer.*, **65** (6), 1296—1299.

SOLOMON, J. D. & W. W. NEEL (1973) Mating behaviour in the carpenterworm moth, *Prionoxystus robiniae. Ann. Ent. Soc. Amer.*, **66** (22), 312—314.

Entomon, 1981, *Vol.* **6**, *No.* 4, *pp.* 335 *to* 341

DEVELOPMENT OF *EUCELATORIA* SP. NEAR *ARMIGERA* (COQ.)[1] ON INSTARS OF *HELIOTHIS ARMIGERA* (HUBN.)

M. MANI & SUDHA NAGARKATTI

National Centre for Biological Control, Indian Institute of Horticultural Research, Bangalore - 80, India

(Received 29 November 1980)

The tachinid fly, *Eucelatoria* sp. nr. *armigera* (Coq.) is currently being bred in the laboratory for subsequent field release for control of *Heliothis armigera* (Hubn.) on several crops. Development of this parasite on 3rd, 4th, early 5th and late 5th instars of *H. armigera* was studied and the results reported. Host larval mortality (23.91%) due to parasite attack occurred only when 3rd instar larvae were parasitised. Higher percentage of parasitism was obtained by exposing 4th and early 5th instar larvae to the mated females. The duration of developmental period of maggots (male and female) decreased with advance in host larval instar parasitised. Puparia period increased generally with development in host larval development. Parasite puparia (male and female) resulting from older host larvae weighed more. The parasitized older larvae (early 5th and late 5th instar) yielded more puparia/host, higher percentage of fly emergence and normal sex ratio. A study of the effect of superparasitism revealed a reduction in maggot and puparial developmental time and puparial weight with increased density of parasites/host. Based on the data obtained in this study, the early 5th instar of *H. armigera* was found as the most suitable stage for the breeding of *E.* sp. nr. *armigera.*

(Key words: Heliothis armigera, Eucelatoria sp. nr. *armigera,* tachinid)

INTRODUCTION

Eucelatoria sp. nr. *armigera* (COQ.) is a common parasite of *Heliothis* spp. in several parts of U S A. An average of 51% parasitism by this parasite on *Heliothis* was observed in field cage studies on cotton (BRYAN *et al.*, 1972). The biology of this tachinid was studied and a mass rearing technique was also developed (JACKSON *et al.*, 1969). Length of development period of *E.* sp. nr. *armigera* and *Eucelatoria armigera* COQ. was determined on *Heliothis virescens* (F.) (BRYAN *et al.*, 1970) and longevity and production of progeny of *E.* sp. nr. *armigera* were also studied (BRYAN *et al.*, 1972). ZISER *et al.*, (1977) reported some effects of superparasitism by this tachinid. This parasitic fly was reared in India on *H. armigera* by SANKARAN & NAGARAJA (1979). Development of *E.* sp. nr. *armigera* in different instars of *H. armigera* has not been studied so far. The present investigation was carried out to obtain information in this aspect and eventually to determine the most favourable stage for rearing *E.* sp. nr. *armigera.*

MATERIALS AND METHODS

Cultures of *E.* sp. nr *armigera* and *H. armigera* were maintained in the laboratory as

[1] Previously referred to as *Eucelatoria armigera* (Jackson *et al.*, 1969) and *Eucelatoria* sp. (Bryan *et al.*, 1970, 1972; Ziser *et al.*, 1977; Ziser and Nettles, 1978).

Contribution No. 1049 of the Indian Institute of Horticultural Research, Bangalore-80.

described by SANKARAN & NAGARAJA (1979) and NAGARKATTI & SATYAPRAKASH (1974) respectively. All rearing and testing was done at 27.7 ± 1.0°C and 68.3 ± 6.9% R H.

Five instars were reported in the larval development of *H. armigera* by BILAPATE *et al.* (1978). Since this tachinid did not prefer to larviposit either in 1st or 2nd instar host larvae, the present study was limited to 3rd, 4th, early 5th and late 5th instars. Fifty larvae in each instar were weighed, individually offered to the mated females for parasitisation and kept in glass vials of 7.5×2.5cm (numbered) individually with artificial diet. Host larvae were inspected daily to determine the parasite developmental period. Puparial formation was recorded at 1—3 hours interval and the puparia from each larva were kept individually in 7.5 × 2.5cm glass vials (labelled). Parasite puparia were weighed 48 hours after formation and were returned to the same vials for observing fly emergence. This was done at one hour intervals during the day only since there was no emergence at night.

Larval instars, weights and percentage of parasitism are given in Table 1. The per cent parasitism was worked out by two methods, i.e., individual exposure and mass exposure. In the first case, larvae were offered by means of a brush individually to the mated females for larviposition. After haemolymph oozed from the puncture in the host larva due to parasite attack, the larvae were returned to the vials with diet. In the latter method twentyfive larvae of each instar were kept at the same time in a cage (30 × 30 × 30 cm) for one hour in which 100 mated females were kept. During this period, cannibalism was avoided by periodically separating the larvae which aggregated. Only the percentage of parasitism was recorded in the mass exposure method.

The formation of one and two puparia in single host larva was found in sufficient numbers in all the instars parasitised. Hence the study on the length of development and puparial weight of the parasite was restricted to those parasitised larvae which yielded one and two puparia host. The data obtained from the early 5th instar parasitised larvae were used to study the effect of superparasitism.

Student's 't' test was employed to find out the difference in developmental time and puparial weight between male and female tachinids. To analyse the difference in length of development and puparial weight among the different larval instars of *H. armigera*, completely randomised block design ('F' test) was applied.

RESULTS AND DISCUSSION

Host larval mortality (21.42%) due to parasitism occurred only in third instar larvae and there was no mortality among other larval instars parasitised. Host mortality of 3rd instar unparasitised was not observed in the present study. Percentage of pupation was 9.52, 11.11 and 8.88 in 3rd, 4th and early 5th instar larvae exposed to parasites respectively but it was 23.91 percent in the late 5th instar larvae. Observation on percentage of parasitism by both the methods of exposure is presented in Table 1. Higher per cent parasitism was recorded in the 4th and early 5th instars in both the methods whereas it was 69.04 and 26.08 percent in the 3rd instar by individual and mass exposure methods respectively.

Host larval mortality before completion of development of internal parasites has been reported by ELSEY & RABB (1970) in case of *Trichoplusia ni* parasitised by the tachinid, *Voria ruralis* and by KING *et al.* (1976) in *Diatraea saccharalis* (F.) parasitised by *Lixophaga diatraeae* (TOWNSEND). In the present case, lower per cent parasitism was observed when 3rd instar larvae were parasitised which may be due to death of host larvae before completion of development of the parasite. In the mass exposure method, the parasites mostly preferred larger larvae since they found difficulty in grasping smaller larvae (3rd instar) for larviposition. Higher percentage of pupation in the late 5th instar larvae may be due to failure of parasite maggots to complete the development in the host as reported by ELSEY & RABB (1970). In genera

TABLE 1. Percentage parasitism by *Eucelatoria* sp. nr. *armigera* by two methods of exposure with different larval instars of *H. armigera*.

Details of host			Per cent parasitism	
Larval instar	Larval age (days)	Larval weight (mg)	Individual exposure	Mass exposure
3rd	6	12.93 ± 5.32	69.04	26.08
4th	8	86.00 ± 20.77	88.88	90.90
5th (early)	10	192.78 ± 38.91	91.30	91.30
5th (late)	13	445.56 ± 62.96	73.91	70.83

TABLE 2. Length of development and puparial weight of *Eucelatoria* sp. nr. *armigera* on different instars of *Heliothis armigera* when one puparium/host larva is obtained.

Larval instar of host	Developmental period of maggot (Days)*			Pupal period (Days)*			Puparial weight (mg)*		
	Male	Female	Mean	Male	Female	Mean	Male	Female	Mean
3rd	6.12^{a}	6.38^{a}	6.25^{a}	8.76	9.21^{b}	8.98^{b}	15.80^{b}	16.14^{b}	15.97^{a}
4th	5.99^{ab}	6.12^{a}	6.12^{ab}	9.19	9.70^{ab}	9.45^{ab}	28.18^{a}	29.00^{a}	28.59^{b}
5th (early)	5.43^{bc}	5.45^{ab}	5.45^{bc}	9.22	9.88^{a}	9.55^{a}	30.71^{a}	31.00^{a}	30.86^{ab}
5th (late)	4.79^{c}	4.82^{b}	4.81^{c}	9.42	9.92^{a}	9.67^{a}	32.00^{a}	33.00^{a}	32.50^{a}
Level of significance	0.01	0.05	0.01	Not significant	0.05	0.01	0.1	0.01	0.01

* Means followed by the same letter do not differ significantly at 5% level by completely randomised block design ('F' test).

4th and early 5th instar larvae were readily accepted by *Eucelatoria* and also fairly higher percentage of parasitism was observed in both the methods of exposure.

Maggot development

The duration of parasite developmental period (male and female) decreased significantly with advance in host larval stage (Table 2). The same trend was observed when two puparia/host were obtained, but the differences in length of developmental period among different larval instars were not statistically significant (Table 3). Developmental period of maggots was always less for males than for females but the difference was not significant. The reduction in developmental period of maggots with advance in development of host larva may be associated with the maggot prefunnel period as reported by MILES & KING (1975) in *L. diatraeae* on *D. saccharalis* and ELSEY & RABB (1970) in *V. ruralis* on *T. ni*. The smaller host larvae may take some time to grow so that they can supply sufficient food to support parasite development. This delay in maggot development is a beneficial adaptation, since had the rate of growth been equal to that in larger host larvae, the host would have

been overwhelmed resulting in death of both host and parasite as concluded by ELSEY & RABB (1970).

Puparial development

Developmental time from puparia formation to adult emergence tended to increase with advancement of host larval development in both male and female parasites. Males emerged earlier than females. Significant differences were observed in the puparia period of males and females when two puparia from a single 4th and early 5th instar parasitised larvae were obtained (Table 3). Increase in duration of puparial period with advancement in development of host larvae that had been parasitised was earlier reported by MILES & KING (1975) but this is unexplained.

Puparial weight

There was significant increase in puparial weight (male and female) with advancement in development of parasitised host larvae. KING *et al.* (1975) reported similar increase in puparial weight of *L. diatraeae* with advancement in host age. MCPHERSON (1975) also reported increasing puparial weight of *L. diatraeae* with increasing host weight. Older host larvae provide more food for the development of parasite maggots resulting in larger puparia.

A male puparium weighed less than that of a female but the difference was not significant. MILES & KING (1976) also reported that weight of male puparia did not differ significantly from female puparia in *L. diatraeae*. Lower weight of male puparia may be due to lower requirement of food than in case of female of *Eucelatoria* sp. (ZISER *et al.*, 1977),

Number of puparia

A mean of 1.21, 1.68, 2.69 and 3.26 puparia/host were recovered from 3rd, 4th early 5th and late 5th instar host larvae respectively. Smaller host larvae could not support the development of a large number of parasite maggots. MILES & KING (1975) reported that younger larvae could support successful development of only one maggot and older larvae could support two/larva.

TABLE 3. Length of development and puparial weight of *Eucelatoria* sp. nr. *armigera* on different instars of *Heliothis armigera* when two puparia/host larva are obtained.

Larval instar of host	Developmental period of maggot (days)			Puarial period (Days)*			Puparial weight (mg)*		
	Male	Female	Mean	Male	Female	Mean	Male	Female	Mean
3rd	5.49	5.60	5.55	8.69	8.76	8.73[b]	9.17[c]	9.50[c]	9.39[c]
4th	5.39	5.78	5.57	8.75	9.33**	9.04[ab]	24.17[b]	24.44[b]	24.31[b]
5th (early)	5.20	5.34	5.27	8.97	9.61**	9.29[a]	27.00[a]	28.25[a]	27.71[a]
5th (late)	5.19	5.26	5.22	9.01	9.80	9.41[a]	30.83[a]	31.00[a]	30.92[a]
Level of significance	Not significant	Not significant	Not significant	Not significant	Not significant	0.05	0.01	0.01	0.01

* Means followed by the same letter do not differ significantly at 5% level by completely randomised block design ('F' test). ** Significantly different from male at 0.05% by Student's 't' test.

Fly emergence

Maximum of 96.46 percent fly emergence was observed when early 5th instar larvae were parasitised, while the yield was lower (80%) from 3rd instar hosts (Table 4). KING *et al.* (1976) found similar results with *L. diatraeae*. An average of 90.7% puparia produced viable adults in *Eucelatoria* sp. according to ZISER *et al.* (1977).

Sex ratio

More males of *E.* sp. nr. *armigera* emerged from puparia obtained from 3rd and 4th instar larvae whereas normal sex ratio of 1:1.16 and 1:1.15 were observed from 5th instar parasitised larvae (early and late).

The early 5th instar of *H. armigera* was the most suitable stage for rearing this tachinid because of its: (1) higher

TABLE 4. Influence of different larval instars of *H. armigera* on the development of number of puparia, fly emergence and sex ratio of *E.* sp. nr. *armigera*.

Larval instar of host	Number of parasite puparia obtained per host larva		Fly emergence (%)	Sex ratio ♀ ♂
	Mean	Range		
3rd	1.21	1—2	80.00	1 : 1.45
4th	1.68	1—3	89.52	1 : 1.83
5th (early)	2.69	1—7	96.46	1 : 1.16
5th (late)	3.26	1—7	93.69	1 : 1:15

TABLE 5. Effect of density of puparia/host larva on the length of development and puparial weight of *E.* sp. nr. *armigera* on early fifth larval instar of *H. armigera*.

Number of puparia/ host larva	Developmental period of parasite maggot*			Puparial period (Days)			Puparial weight (mg)*		
	Male	Female	Mean	Male	Female	Mean	Male	Female	Mean
1	5.43^{a}	5.48^{a}	5.45^{a}	9.22	9.88	9.55	30.71^{a}	31.00^{a}	30.86^{a}
2	5.34^{a}	5.25^{a}	5.29^{ab}	8.97	9.80	9.44	27.00^{bc}	28.25^{a}	27.25^{b}
3	4.98^{ab}	5.05^{b}	5.01^{bc}	9.30	9.79	9.50	25.10^{c}	24.29^{b}	24.76^{c}
4	4.77^{b}	4.99^{b}	4.88^{cd}	8.84	9.60**	9.23	21.38^{d}	22.29^{bc}	21.85^{d}
5	4.17^{c}	4.83^{b}	4.57^{d}	9.00	9.25	9.15	17.00^{de}	18.00^{cd}	17.50^{a}
6	4.00^{c}	4.04^{c}	4.02^{e}	8.94	9.29**	9.11	14.67^{e}	14.50^{c}	14.58^{e}
7	3.74^{c}	3.92^{c}	3.79^{e}	9.19	9.12	9.17	13.40^{e}	14.50^{d}	13.95^{e}
Level of significance	0.01	0.01	0.01	Non-significant	Non-significant	Non-significant	0.01	0.01	0.01

* Means followed by the same latter do not differ significantly at 5% level by completely randomised block design ('F' test). ** Significantly different from male at 5% level by Student's 't' test.

acceptability; (2) higher percentage of parasitism; (3) lower incidence of pupation of host exposed to the parasite; (4) comparatively higher puparia weight; (5) higher percentage of fly emergence and (6) normal sex ratio.

Effect of density of puparia/host on the length of development and puparial weight

Since we found early 5th instar *H. armigera* larvae to be ideal for breeding this parasite, the effect of super parasitism was studied on this instar but only on a limited scale, since ZISER *et al.* (1977) have already reported in detail the effects of density of maggots/host of *Eucelatoria* sp. on *H. virescens*. The duration of development period of the maggots (both the male and female) significantly decreased with increasing parasite density (Table 5). Males developed in shorter time than females but again the difference was not significant when more parasite maggots were deposited in a single larva, the contents of the body were consumed more rapidly by the maggots resulting in rapid puparia formation. This may be the reason for a shorter developmental time when density of parasites/host increased and vice-versa.

The duration of puparial period was significantly reduced when the density of puparia/host increased, especially in case of female parasites, but there was no definite trend in males. Males emerged first and there was no significant difference in the puprial period between male and female parasites except when four and six puparia/host were obtained.

Puparial weight (males and females) decreased significantly as the density of puparia/host increased. Female puparial weight was always more than that of males regardless of the density of parasites/host but the difference was not significant. All the above results agree with those of ZISER *et al.* (1977) who studied the effects of superparasitism by *Eucelatoria* sp. on *H. virescens*. Decrease in puparia weight of *L. diatraeae* with increasing maggot density in *D. saccharalis* was also reported by KING *et al.* (1976).

Because of higher percentage of parasitism, more puparia/host, higher percentage of fly emergence and normal sex ratio, the early fifth instar larva was found to be the most suitable stage for breeding this tachinid. For a number of characters studied, early and late 5th instar larvae were on par but the former were more readily accepted by the parasite than the latter.

Acknowledgement:—The authors acknowledge the help given by Dr. K. NARAYANAN, Mr. B. MANOHAR and Mr. T. G. NANDAKISHORE in the present study. They also thank the Director, Indian Institute of Horticultural Research, Bangalore for providing facilities.

REFERENCES

BILAPATE, G. G., V. M. PAWAR & A. K. RAODEO (1978) Biometrical analysis of growth in the larvae of *Heliothis armigera* (HUBN.). *Proc. Indian Acad. Sci.*, **87B**, 349—3 5.

BRYAN, D. E., C. G. JACKSON & R. PATANA (1970) Biological Comparison of two species of *Eucelatoria* parasitic in *Heliothis* spp. *J. econ. Ent.*, **63**, 1469—1472.

BRYAN, D. E., C. G. JACKSON, E. G. NEEMAN & R. PATANA (1972) Production of progeny and longevity of *Eucelatoria* sp. parasitic on *Heliothis* species. *Environ. Ent.*, **1**, 23—26.

ELSEY, K. D. & R. L. RABB (1970) Biology of *Voria ruralis* (Diptera: Tachinidae). *Ann. ent. Soc. Amer.*, **63**, 216—222.

JACKSON, C. G., D. E. BRYAN & R. PATANA (1969) Laboratory studies of *Eucelatoria armigera*, a tachinid parasite of *Heliothi* spp. *J. econ. Ent.*, **62**, 907—910.

KING, E. G., L. R. MILES & D. F. MARTIN (1976) Some effects of superparasitism by *Lixophaga diatraeae* of sugarcane borer larvae in the laboratory. *Ent. exp. & Appl.*, **20**, 201—269.

*MCPHERSON, R. M. (1975) The potential of *Lixophaga diatraeae* TOWNS. (Diptera: Tachinidae) in Louisiana. M. S. Thesis, Louisiana State University Library, Bataon Rouge, L. A.

MILES L. R. & E. G. KING (1975) Development of the tachinid parasite, *Lixophaga diatraeae* on various developmental stages of sugarcane borer in the laboratory. *Environ. Ent.*, **4**, 811—814.

NAGARKATTI, S. & SATYA PRAKASH (1974) Rearing *Heliothis armigera* (HUB.) on an artificial diet. *Tech. Bull. Commonw. Inst. Biol. Control.*, **17**, 169—173.

SANKARAN, T. & H. NAGARAJA (1979) A note on *Eucelatoria* sp. nr. *armigera* (COQ.) (Diptera, Tachinidae) imported from U S A for trial against *Heliothis armigera* (HUB.) (Lep. Noctuidae) in India. *Entomon*, **4**, 379—381.

ZISER, S. W. & W. C. NETTLES, Jr. (1978) The larval development of *Eucelatoria* sp. in the host, *Heliothis virescens*. *Ann. ent. Soc. Amer.*, **71**, 383—388.

ZISER, S. W., J. A. WOJ TOWCIZ & W. C. NETTLES (1977) The effects of the number of maggots per host on length of development. puparial weight and adult emergence of *Eucelatoria* sp. *Ann. ent. Soc. Amer.*, **70**, 733—736

---

* Original not seen

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 343 *to* 350

FIVE NEW SPECIES OF *ANTHOCOPTES* NALEPA (1892) (ERIOPHYIDAE : ACARINA) FROM SOUTH INDIA

M. MOHANASUNDARAM

Cashew Research Station, Vridhachalam, India 606 001

(*Received 20 July 1980*)

The paper presents descriptions and figures of five species of *Anthocoptes* Nalepa (1892) which are new to science. They are *A. ayyanari*, sp. nov., *A. pavoniae* sp. nov., and *A. walayarensis* sp nov. Their affinities to the known species are also given.

(*Key words:* new *Anthocoptes* from India)

In this paper five species of *Anthocoptes* Nalepa (1892) have been described and adequately figured.

The types and paratype slides are deposited in the Department of Agricultural Entomology Collections, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, 641-003, India.

1. Anthocoptes ayyanari sp. nov. (Figs. 1-9).

This mite belongs to the group of *Anthocoptes* with 6 rayed feather claw and resembles *Anthocoptes depressus* Farkas (1963) but differentiated from it by the clear genital cover flap and the faint lines on the shield apart from the measurements. It is differentiated from *Anthocoptes bakeri* Keifer (1959) by the 5 rayed feather claw and the clear genital coverflap.

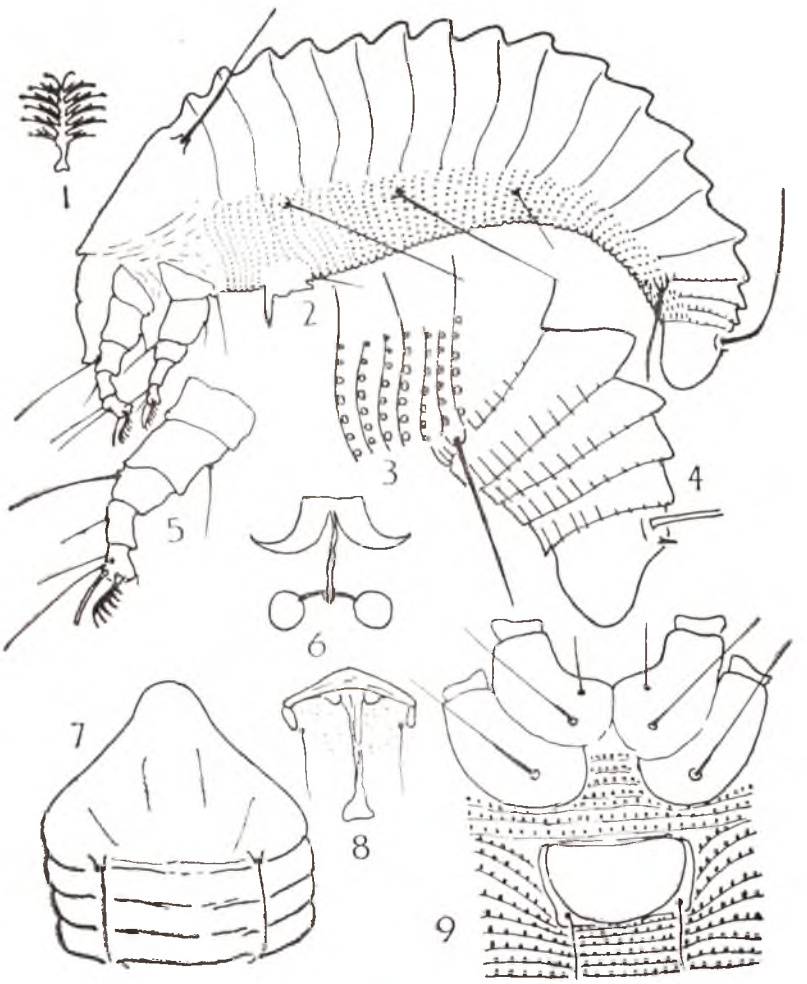
Female:[1] 130—140 long; 50 wide; rostrum 15 long, evenly down curved; antapical seta 4 long. Shield 30 wide, 30 long with short faintly represented admedians and submedians. Dorsal tubercles on the shield margin, 20 apart; dorsal seta 16 long, pointing backward. Foreleg 20 long; tibia 5 long; tibial seta 3 long at basal 1/3; tarsus 5 long; claw 5 long; feather claw 6 rayed; femoral, patellar, tibial and tarsal setae present. Hind leg 20 long; tibia 4 long; tarsus 4 long; claw 7 long. Coxae broadly joined; with all three setiferous tubercles; seta I, 8 long; seta II, 24 long; seta III, 25 long; coxal area smooth. Abdomen with about 16—18 broad, smooth tergites, 65 microtuberculate sternites; lateral seta 13 long on ring 8; first ventral seta 37 long on ring 25; second ventral seta 10 long on ring 40; third ventral seta 12 long on ring 5 from behind; caudal seta 40 long; accessory seta 1 long. Female genitalia 16 wide; 8 long; coverflap smooth without any lines; genital seta 17 long.

Male: 130—135 long; 37 thick, genitalia 13 wide; genital seta 15 long.

Types: A **holotype** slide with 3 ♀♀ and 6 **paratype** slides with 3 ♂♂ and 3 ♀♀, INDIA, TAMIL NADU, District South Arcot, Villupuram Taluk, Sendanur Ayyanar Temple (Near Railway Station), 17. viii. 1975, Coll. Mohanasundaram (No. 185).

Remarks: Mites collected from an unidentified tree, found in the buds.

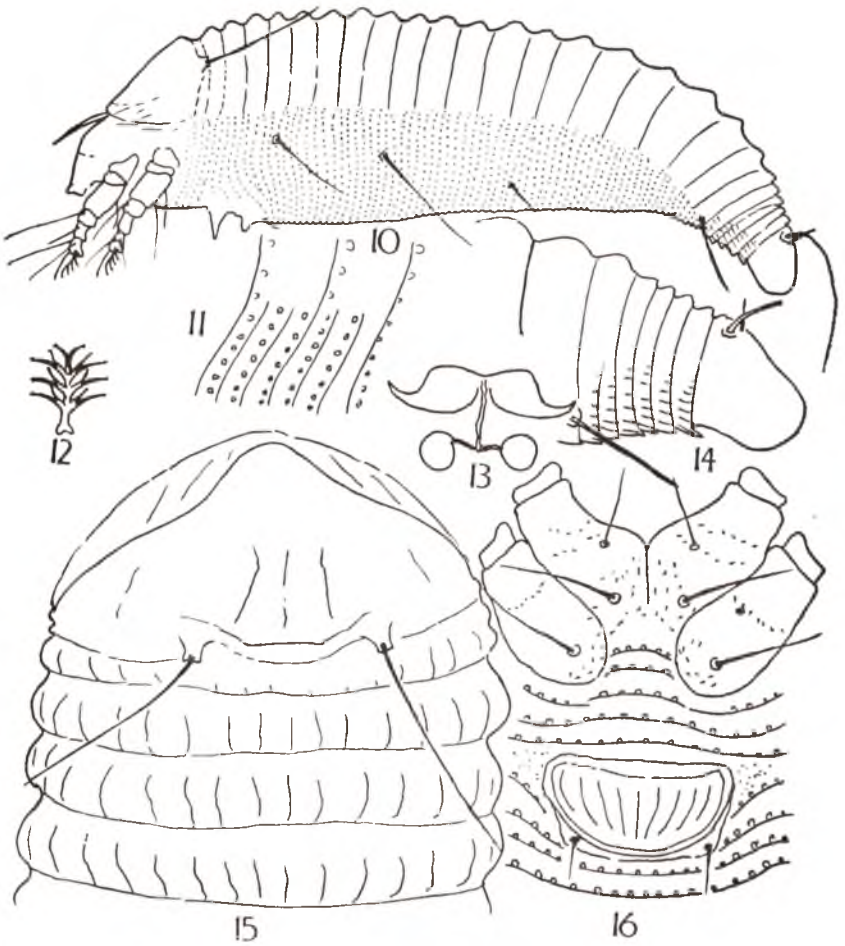
[1] All measurements of length are in μm, unless otherwise specified.



Anthocoptes ayyanari sp. nov. (Figs. 1—9). 1. Feather claw; 2. Side view of mite; 3. Side skin structure; 4. Side view of cauda; 5. Left foreleg; 6. Internal female apodeme; 7. Dorsal view of shield; 8. Male genitalia; 9. Female genitalia and coxae from below.

2. Anthocoptes pavoniae sp. nov. (Figs. 10—16).

This species is near *Anthocoptes helianthellae* Keifer (1962) by its 4 rayed feather claw but differs from it by the scorings on the sides of shield and by the larger number of tergites in the abdomen. It differs from *Anthocoptes tectonae* sp. nov. described in this paper, by the shield design. It also differs from the other 4 rayed feather claw mite, *Anthocoptes gutierreziae* Keifer (1962) by its shield design and larger number of tergites.



Anthocoptes pavoniae sp. nov. (Figs. 10—16). 10. Side view of mite; 11. Side skin structure; 12. Feather claw; 13. Internal female apodeme; 14. Side view of cauda; 15. Dorsal view of shield; 16. Female genitalia and coxae from below.

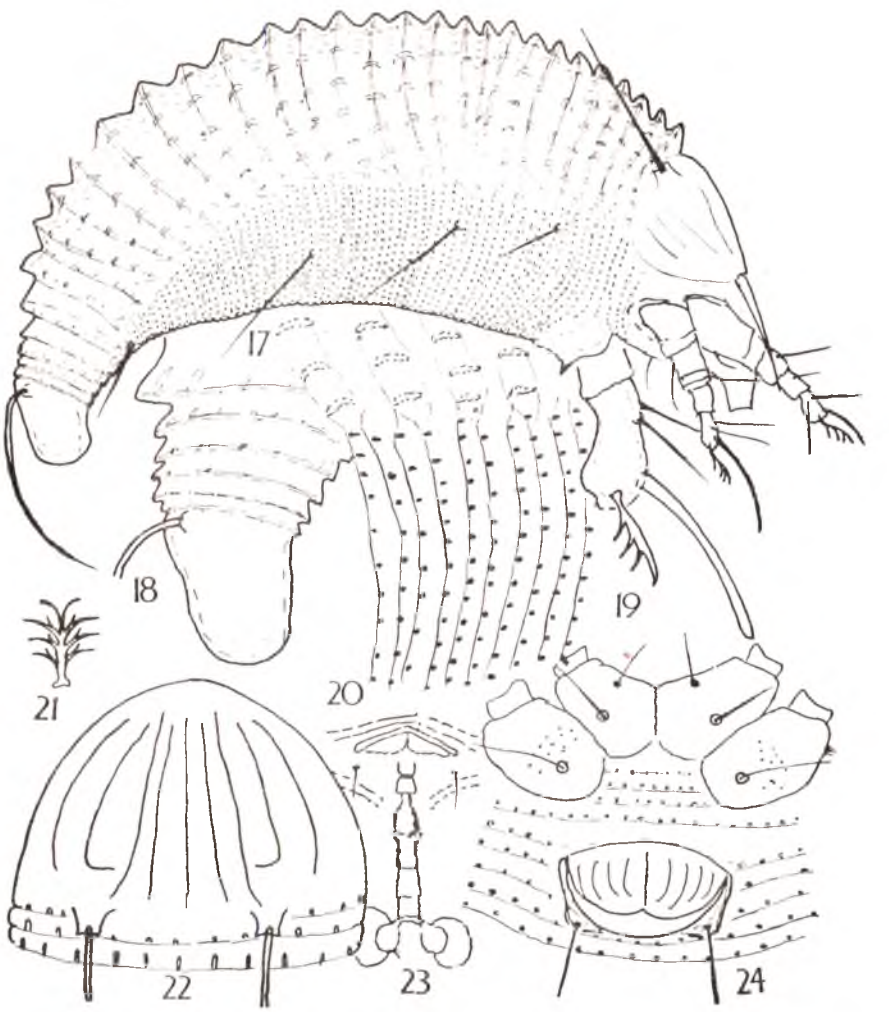
Female: 200—210 long; 50 thick; rostrum 13 long, pointing obliquely forward and downward; antapical seta 3 long. Shield triangular, 40 wide and 20 long; median line and admedians faintly represented at the rear shield margin and submedian as short line on either side; sides of shield with few oblique lines; dorsal tubercles on rear shield margin, 18 apart; dorsal seta 26 long; pointing backward and outward. Foreleg 25 long; tibia 5 long; tibial seta 4 long; at basal 1/3, tarsus 6 long; claw 6 long, fairly straight, feather claw 4 rayed; femoral, patellar, tibial and tarsal setae present. Hindleg 22 long; tibia 4 long; tarsus 4 long; claw 8 long; femoral, patellar and tarsal setae present. Coxal area granular in the forecoxae; sparsely granular on the hind coxae; all three setiferous tubercles present: seta I, 10 long seta II, 15 long; seta III, 16 long. Abdomen with broad tergites, 25—28 in num-

ber, with faint elongate microtuberculation and 57—60 finely microtuberculate sternites; last few segments with narrow rings; lateral seta 18 long on ring 10; first ventral seta 30 long on ring 20; second ventral seta 8 long on ring 32; third ventral seta 15 long on ring 6 from behind; caudal seta 50 long; accessory seta 4 long; female genitalia 18 wide and 10 long, coverflap with 10—12 lines; genital seta 5 long.

Male: Not known.

Types: A **holotype** slide and 6 **paratype** slides all with ♀♀, INDIA, TAMIL NADU, Coimbatore. Siruvani Hills near falls, 25. vii. 1976, Coll. Mohanasundaram (No. 247).

Host: *Pavonia* sp. Malvaceae. The mites cause white erineum patches on both sides of the leaf.



Anthocoptes tectonae sp. nov (Figs. 17—24). 17. Side view of mite; 18. Side view of cauda; 19. Feather claw; 20. Side skin structure; 21. Feather claw; 22, Dorsal view of shield; 23. Male genitalia; 24. Female genitalia and coxae from below.

3. Anthocoptes tectonae sp. nov. (Figs. 17—24).

This species resembles *Anthocoptes shepherdiae* Keifer (1966) by its microtuberculation, but differ by the shield design, 4 rayed feather claw and the clear forecoxal area. It differs from the other 4 rayed feather claw mites like *Anthocoptes gutierreziae* Keifer (1962) and *Anthocoptes helianthellae* Keifer (1962) by its very characteristic clear shield lines.

Female: Mites white, worm like, curved, 160—170 long, 44 thick; rostrum 12 long, evenly down curved, antapical seta short, 2 long. Shield triangular, 28 wide and 20 long, with a distinct design. Median line straight, admedians straight, slightly converging anteriorly, first submedian straight parallel to admedians; second submedians slightly curved with an abrupt bend near the rear shield margin; third submedian arched and passes along the shield margin; sides of shield clear. Dorsal tubercles at shield margin; 16 apart; dorsal seta 25 long; projecting caudad. Fore leg 22 long; tibia 2.5 long, tibial seta at about 1/3 from base, 3 long; tarsus 5.5 long; claw 5.5 long, slightly curved; feather claw 4 rayed. The femoral, patellar, tibial and tarsal setae present. Hind leg 19 long; tibia 3.5 long; tarsus 5.5 long; claw 8 long; fairly straight, tapering and blunt at tip. The femoral, patellar and tarsal setae present. Coxae fairly smooth except for a few granulations in the hind coxae; all three setiferous tubercles present, placed wider apart from mid line; seta I, 6 long; seta II, 8 long; seta III, 12 long. Abdomen with about 35 broad distinct tergites and 60—70 narrow sternites. Tergites with faint, elongated, widely placed microtuberculation; sternite with closely set, round microtubercles along the posterior margin of each ring. Lateral seta 11 long on ring 13; first ventral seta 40 long on ring 25; second ventral seta 7 long on ring 39; third ventral seta 15 long on ring 6 from behind; caudal seta 50 long; accessory seta 2 long. Female genitalia 16.5 wide and 10 long, coverflap with 8—10 lines; genital seta 5 long, very thin.

Male: Not known.

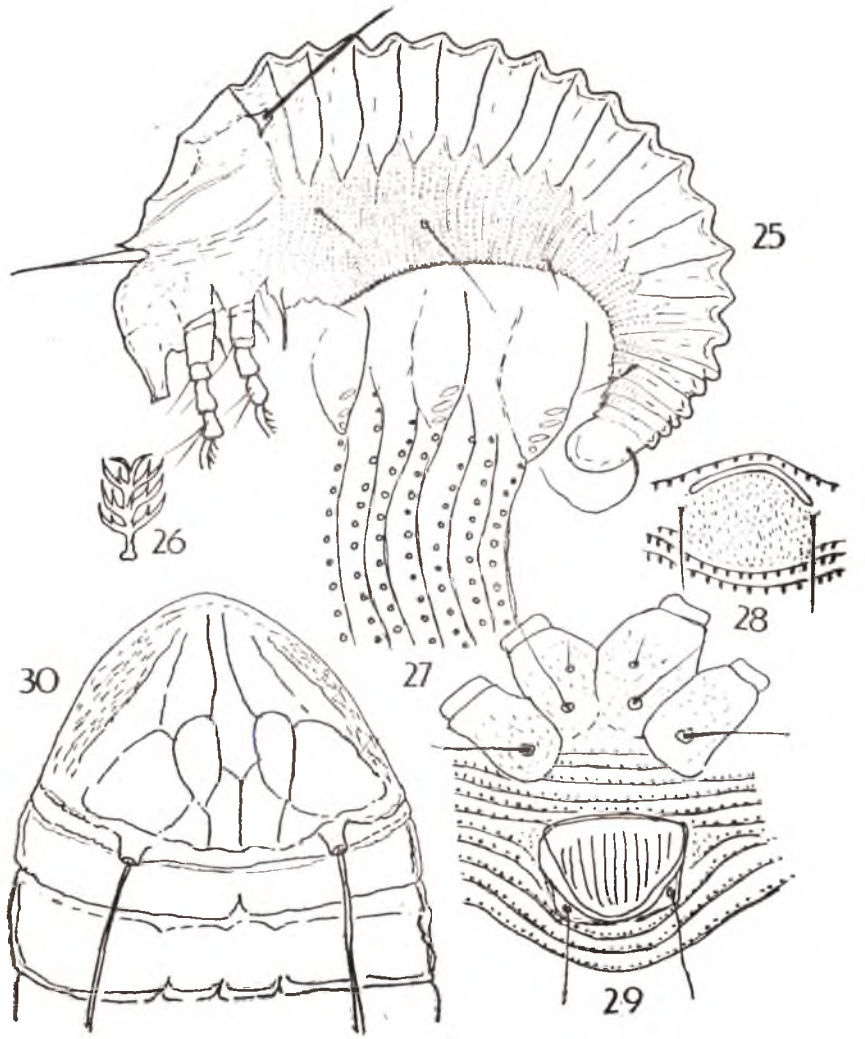
Types: A **holotype** slide and 5 **paratype** slides all with ♀♀, INDIA, TAMIL NADU, Kallar, Fruit Research Station, 16. v. 1973, Coll. Mohanasundaram (No. 59).

Host: Tectona grandis Linn. (Verbenaceae). Mites on lower side of leaf, among hairs. No symptoms.

4. Anthocoptes vitexae sp. nov. (Figs. 25—30).

This species resembles *Anthocoptes shepherdiae* Keifer (1966) in its general appearance but differentiated by the shield pattern, 4 rayed feather claw, longer shield setae and the tergites without microtuberculation. It differs from other 4 rayed feather claw mites like *Anthocoptes gutierreziae* Keifer (1962) and *Anthocoptes helianthellae* Keifer (1962) by the clear cut shield pattern.

Female: Mites white, worm like, 160—175 long; 40 thick; rostrum 20 long; evenly down curved; antapical seta 5 long. Shield 30 wide and 22 long, with a clear pattern of lines. Median line represented at the basal 1/3, forked anteriorly joins the admedians; admedians wavy, complete, forked posteriorly and joining with the submedians forming cells. First submedians wavy, forked posteriorly, forming cells with the admedians. Second submedian forms the border of the shield. Sides of shield granular with small lines. Dorsal tubercles on rear shield margin, 20 apart, tubercles and setae pointing backwards; dorsal seta 28 long.



Anthocoptes vitexae sp. nov. (Figs. 25—30). 25. Side view of mite; 26. Feather claw; 27. Side skin structure; 28. Male genitalia; 29. Female genitalia and coxae from below; 30. Dorsal view of shield.

Fore leg 28 long; tibia 7 long; tibial seta 4 long at middle, tarsus 5 long; claw 5.5 long, slightly curved and tapering; feather claw 4 rayed. Foreleg with the usual femoral, patellar, tibial and tarsal setae. Hind leg 25 long; tibia 5.5 long; tarsus 5 long; claw 7.5 long; with femoral, patellar and tarsal setae. Coxae granular; first and second setiferous tubercles nearer the central line, third situated wider apart; seta I, 5 long; seta II, 15 long; seta III, 18 long. Abdomen with about 22—25 tergites, and 60 sternites; tergites broad and without microtuberculation; sternites with fine dot like microstriations at the posterior 1/3 of each ring; becomes

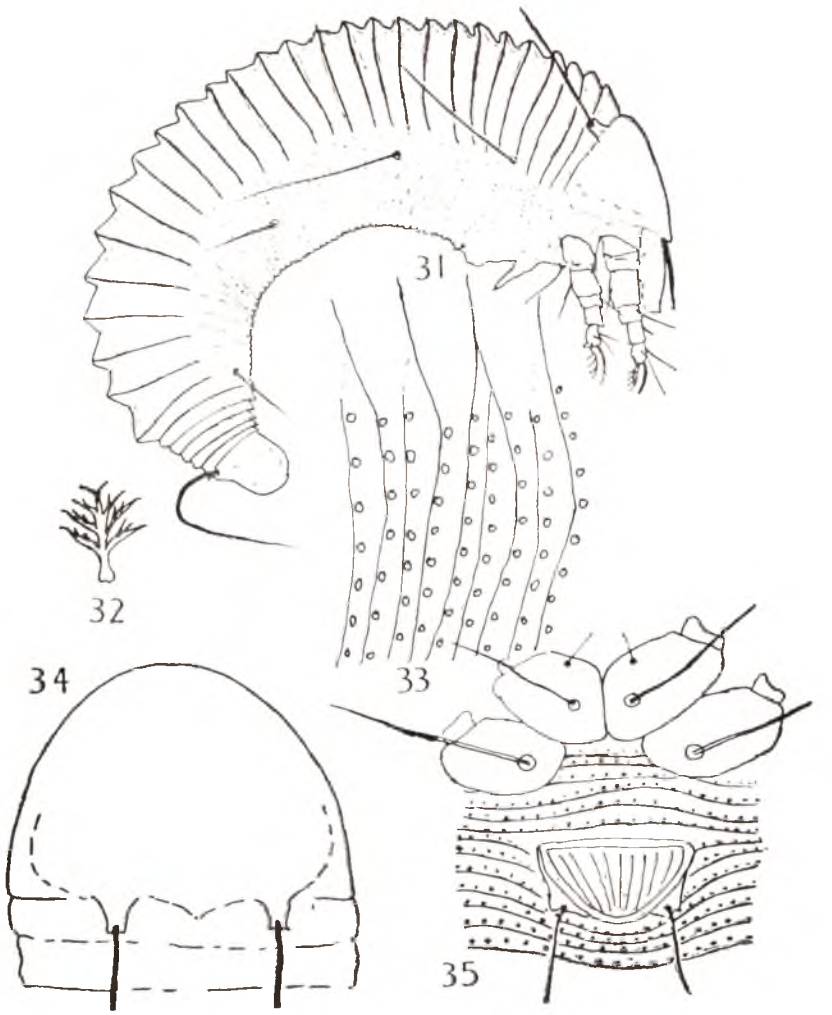
elongated towards the posterior segments and found as definite microstriations in the last 10 segments. Lateral seta 22 long on ring 11; first ventral seta 44 long on ring 22; second ventral seta 20 long on ring 37; third ventral seta 22 long on ring five from behind; caudal seta 60 long; accessory seta 2.5 long. Female genitalia 15 wide and 10 long; coverflap with 10—12 lines; genital seta 16 long.

Male: Not known.

Types: A **holotype** slide and six **paratype** slides, all with ♀♀, INDIA, TAMIL NADU Villupuram Taluk, Valavanur, 12. i. 1973, Coll. Mohanasundaram (No. 42).

Host: *Vitex negundo* Linn. (Verbenaceae). Mites vagrants on tender foliage and buds.

5. Anthocoptes walayarensis sp. nov. (Figs. 31—35).



Anthocoptes walayarensis sp. nov. (Figs. 31–35). 31. Side view of mite; 32. Feather claw; 33. Side skin structure; 34. Dorsal view of shield; 35. Female genitalia and coxae from below.

This species resembles *Anthocoptes adathodae* Channabasavanna (1966), but could be differentiated by the number of tergites, size, shape of shield, length of claw and coxae. The new species form erineum patches and deforms the leaves while *A. adathodae* is found as leaf vagrants and among buds. This is also differentiated from other 4 rayed feather claw mites like *A. gutierreziae* and *A. helianthellae* (Keifer, 1962), by the rounded anterior shield margin; clear coxal area, the number of scorings on the female genital coverflap and the number of tergites.

Female: White, worm like, curved, 150-170 long, 40 thick, rostrum 15 long, evenly down curved; antapical seta 3 long; shield triangular, rounded anterior lobe overhanging rostrum base; shield 22 wide, 18 long without any markings dorsally as well as on the sides; dorsal tubercles 10 apart, prominent, on rear shield margin; dorsal setae 24 long, pointing caudad. Fore leg 25 long; tibia 3 long; tibial seta 3 long at about middle; tarsus 5 long; claw 8 long; feather claw 4 rayed; femoral, patellar, tibial and tarsal setae present. Hindleg 23 long; tibia 3 long; tarsus 4 long; claw 10 long; femoral, patellar and tarsal setae present. Coxae closely appressed, first setiferous coxal tubercles at anterior end of fore coxae, second setiferous tubercles in line with the first at middle of forecoxae; third setiferous tubercles placed wider apart at middle of hind coxae; seta I, 6 long; seta II, 25 long; seta III, 27 long; coxal area clear. Abdomen with 32—35 tergites and 62—65 sternites, telosomal rings complete. Tergites broad and smooth, sternites uniformly microtuberculate, microtubercles round and dot like; telosomal sternites with microstriations. Lateral seta 20 long on sternite 8; first ventral seta 60 long on sternite 21; second ventral seta 12 long on sternite 36; third ventral seta 20 long on ring 6 from behind; caudal seta 50 long; accessory seta 5 long. Female genitalia 15 wide and 10 long; coverflap with 8—10 lines; genital seta 4 long.

Male: Not known.

Types: A **holotype** slide and 10 **paratype** slides all with ♀♀. INDIA, TAMIL NADU, Nalayar Forest, Kerala Tamil Nadu border, 28.iii.1972, Coll Mohanasundaram (No. 53) *Host*: Unidentified tree. The leaves are crinkled, deformed and pitted due to erineum formation.

REFERENCES

CHANNASASAVANNA, G. P. (1966) A contribution to the knowledge of Indian Eriophyid mites (Eriophyoidea : Trombidiformes : Acarina). *Univ. agric. Sci. Bangalore, Bull.*, 153 pp.

FARKAS, H. K. (1963) On the Eriophyids of Hungary. IV. *Ann. Hist. Nat. Mus. Nation. Hung. Pars. Zool.*, 9 (3—4), 237—270.

KEIFER, H. H. (1959) Eriophyid studies. xxviii. *Bull. Ent. Calif. Dept. Agric. Occasional Papers*, No. P. 2.

KEIFER, H. H. (1962) Eriophyid Studies *B. 7. Bull. Ent. Calif. Dept. Agric.*, 20 pp.

KEIFER, H. H. (1966) Eriophyid Studies *B. 21 Bull. Ent. Calif. Dept. Agri.*, 24 pp.

NALEPA, A. (1892) Neue Gallmilben. 5. *Anz. Akad. Wien.*, **29**, 190 - 192.

Entomon, 1981, *Vol.* 6, *No.* 4, *pp* 351 *to* 355

POPULATION STUDIES OF JUJUBE LEAF-WEBBERS ON *ZIZYPHUS MAURITIANA* LAMK. AT LUDHIANA (PUNJAB)

G. S. MANN & DHARAMPAUL SINGH

Department of Entomology, Punjab Agricultural University, Ludhiana, India

(Received 25 August 1980)

Population studies of jujube leaf-webbers viz., *Synclera univocalis* Walker, *Ancylis lutescens* Meyr, *Limaecia* sp. and an unidentified species, which were carried out during 1978—1979 in the jujube *(Zizyphus mauritiana* Lamk.) orchard of the Punjab Agricultural University, Ludhiana revealed that the jujube webbers are serious pests owing to their high populations and *Synclera univocalis* Walker is a dominant species among the jujube webbers. The mean pooled population of the webbers feeding on the jujube trees varied from 17.00 to 63.00 larvae + pupae / 100 leaves, with an average of 39.50 ± 15.75 larvae / 100 leaves. There were three peaks of population; one in August and September, second in January and third in April—May. The highest population was in May and it differed significantly from all other months excepting August. The minimum population was in June and it differed significantly from all other months. The presence of all stages of the webbers at a time throughout the year suggests that these insects had overlapping of generations and are active throughout the year

(Key words: population studies, population structure, jujube webbers)

INTRODUCTION

About 50 species of insects were reported to damage the jujube *(Zizyphus mauritiana* LAMK.) orchards in India (WADHI & BATRA, 1964). The leaf webbers, *Synclera univocalis* WALKER, *Ancylis lutescens* MAYR, *Limaecia* sp. and an unidentified species, are the important pests of jujube in the Punjab and among these, *S. univocalis* was dominant one. The larvae turn the margin of the leaves by the help of silken threads and feed within. The advanced stages of larvae may eat all the green portion of the leaves leaving behind only papery epidermis. On an average a single larva of *S. univocalis* in its life span consumed 7.11 cm^2 of leaf on area basis and 0.135 g of green tissue on weight basis. Mostly one larva/leaf was present and 67.8 per cent of the larvae preferred the single leaf web. The huge loss in the food synthesising material (leaves) results in a tremendous loss to the vigour of the trees. In view of the serious nature of the problem, this study was initiated.

MATERIALS AND METHODS

During 1978—1979 the counts of larvae and pupae of different species of jujube leaf-webbers were taken in the jujube *(Zizyphus mauritiana* LAMK var. *umran*) orchard of the Punjab Agricultural University at Ludhiana. The counts were made by observing 100 leaves (25 from each side of the tree) randomly for larval and pupal counts. The observations were taken at weekly interval during 1978—1979. There were five replications and each tree served as one replication. The counts of larvae and pupae of different species of webbers involved were kept separately.

RESULTS AND DISCUSSION

Population studies: The population counts of difierent species of jujube

webbers which were taken during 1978—1979 are as follows:

1. *Synclera univocalis* : The mean larval and pupal population per 100 leaves varied from 11.40 to 48.25 and 1.75 to 11.75 respectively and the averages were 29.15 and 6.15 for larvae and pupae respectively (Table 1). The pooled mean population of larvae and pupae per 100 leaves varied from 15.00 to 57.00 and the average being 35.50. There were three peaks of populations; one in July to September, second in December to January third in April—May (Fig. 1).

2. *Ancylis lutescens* : The mean larval population varied from 0.50 to 4.75 larvae/ 100 leaves. There were two peaks of the population, one in May and other in January. The population in May was significantly higher than all the other months excepting January. The pooled (larval + pupal) population ranged from 0.75 to 6.25 larvae + pupae/100 leaves (Table 1; Fig. 1).

3. *Limaecia* sp. : The mean larval + pupal population varied from 0.25 to 2.00 larvae+pupae per 100 leaves (Table 1) in different months and the differences were non-significant.

4. *Unidentified sp.* : During different months the mean larval+pupal population varied from 0.25 to 1.50 larave + pupae per 100 leaves (Table 1) and there was no significant difference in population of different months.

The mean pooled population of the webbers (*S. univocalis*, *A. lutescens*, *Limaecia* sp. and an unidentified sp.) feeding on the jujube trees varied from 17.00 to 63.00 larvae + pupae/100 leaves, with an average of 39.50 ± 15.75 larvae + pupae/ 100 leaves (Table 1). There were three

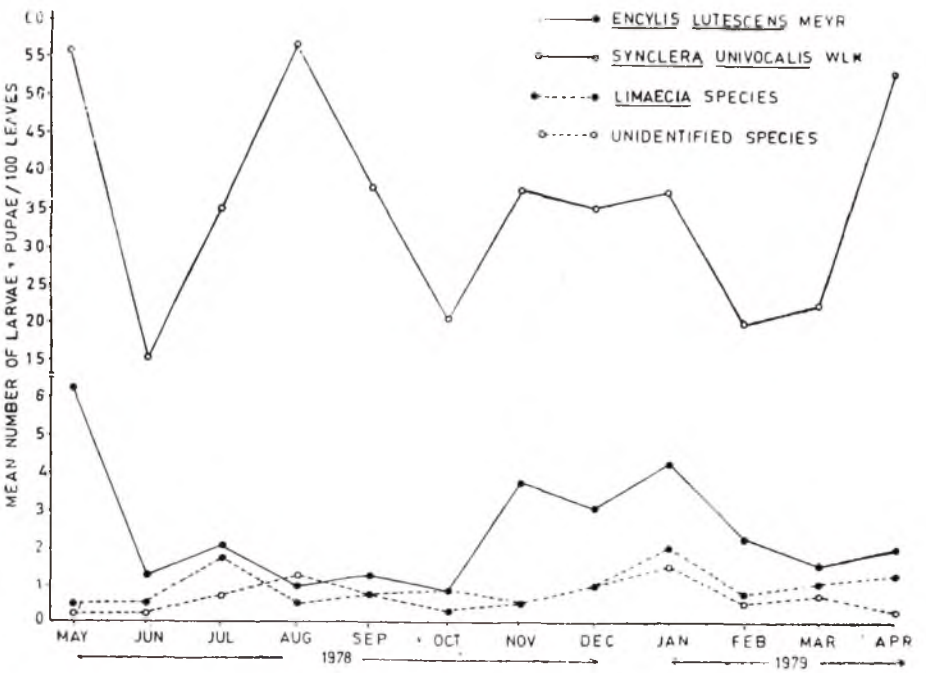


Fig. Population fluctuation of different species of leaf-webbers on jujube during 1978—1979.

TABLE 1. Population fluctations of *Synclera univocalis* WALKER, *Anclis lutescens* MEYR., *Limaecia* sp. and an unidentified species during 1978—1979.

Month	*S. univocalis*			*A. lutescens*			*Limaecia* sp.			Unidentified sp.			Total
	Larval	Pupal	Larval + pupal	Larval	Pupal	Larval + pupal	Larval	Pupal	Larval + pupal	Larval	Pupal	Larval + pupal	larval + pupal
1	2	3	4	5	6	7	8	9	10	11	12	13	14
	*Mean population per 100 leaves												
May	48.25 (6.90)[a]	7.75 (2.73)[bcd]	56.00 (7.42)[a]	4.75 (2.39)[a]	1.50	6.25 (2.69)[a]	0.25	0.25	0.50	0.25	0.00	0.25	63.00 (7.93)[a]
June	11.40 (3.37)[e]	3.60 (1.83)[ef]	15.00 (4.74)[c]	0.50 (1.20)[d]	0.75	1.25 (1.49)[f]	0.50	0.00	0.50	0.25	0.00	0.25	17.00 (4.11)[f]
July	29.80 (5.44)[bc]	5.20 (2.24)[cde]	35.00 (5.89)[b]	1.50 (1.53)[cd]	0.50	2.00 (1.70)[cdef]	1.50	0.25	1.75	0.50	0.25	0.75	39.50 (6.28)[d]
Aug.	48.00 (6.91)[a]	9.00 (2.96)[ab]	57.00 (7.52)[a]	0.75 (1.31)[d]	0.25	1.00 (1.39)[ef]	0.25	0.25	0.50	0.75	0.50	1.25	59.50 (7.71)[ab]
Sep.	33.25 (5.76)[b]	4.75 (2.13)[de]	38.00 (6.16)[b]	1.00 (1.39)[d]	0.25	1.25 (1.49)[ef]	0.50	0.25	0.75	0.50	0.25	0.75	40.75 (6.38)[d]
Oct.	16.75 (4.06)[d]	3.50 (2.06)[e]	20.25 (4.47)[c]	0.50 (1.21)[d]	0.25	0.75 (1.29)[f]	0.25	0.00	0.25	0.75	0.00	0.75	22.50 (4.74)[c]
Nov.	25.75 (5.06)[c]	11.75 (3.42)[a]	37.50 (6.12)[b]	2.75 (1.91)[bc]	1.00	3.75 (2.16)[bc]	0.50	0.00	0.50	0.50	0.00	0.50	42.00 (6.48)[cd]
Dec.	33.25 (5.76)[b]	1.75 (1.29)[f]	35.00 (5.91)[b]	2.75 (1.92)[bc]	0.25	3.00 (1.96)[bcd]	0.75	0.25	1.00	0.75	0.25	1.00	39.50 (6.28)[d]
Jan.	31.00 (5.56)[bc]	6.25 (2.47)[bcde]	37.25 (6.09)[b]	3.50 (2.11)[ab]	0.75	4.25 (2.27)[ab]	1.25	0.75	2.00	1.00	0.50	1.50	45.00 (6.71)[c]

(Contd....)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Feb.	11.75 (3.42)^{e}	8.00 (2.82)^{a1e}	19.75 (4.44)^{e}	1.50 (1.57)^{cd}	0.75	2.25 (1.80)^{bcde}	0.50	0.25	0.75	0.25	0.25	0.50	23.25 (4.82)^{e}
March	16.25 (4.05)^{d}	6.00 (2.43)^{bcde}	22.25 (4.74)^{e}	1.00 (1.36)^{d}	0.50	1.50 (1.78)^{cde}	0.75	0.25	1.00	0.50	0.25	0.75	25.50 (5.05)^{e}
April	46.75 (6.83)^{a}	6.25 (2.48)^{bcde}	53.00 (7.26)^{a}	1.25 (1.49)^{d}	0.75	2.00 (1.70)^{cdef}	1.00	0.25	1.25	0.00	0.25	0.25	56.50 (7.52)^{b}
Total/ Mean	352.20/ 29.35	73.80/ 6.15	426.00/ 35.50	21.75/ 1.81	7.50/ 0.63	29.25/ 2.44	8.00/ 0.67	2.75/ 0.23	10.75/ 0.90	6.00/ 0.50	2.50/ 0.21	8.50/ 0.71	39.50± 15.72
F test	*	*	*	*	NS	*	NS	NS	NS	NS	NS	NS	*
CD (p=0.05)	0.58	0.64	0.98	0.41	—	0.48	—	—	—	—	—	—	0.32

*Mean of 4 observations. Figures followed by the same letter in a given column did not differ significantly. Parentheses are $\sqrt{n}$ in *S. univocalis* and total larval + pupal column and $\sqrt{n+1}$ in *A. lutescens* columns.

TABLE 2. Proportion of the jujube leaf webbers.

Species	Mean population/100 leaves during 1978—1979			
	Larval	Pupal	Larval + pupal	Percentage of larval+ pupal population
S. univocalis WALKER	29.35	6.15	35.50	89.7
A. lutescens MEYR	1.81	0 63	2.44	6.2
Limaecia sp.	0.67	0.23	0.90	2.3
Unidentified sp.	0.50	0.21	0.71	1.8

peaks of population; one in August and September, second in January and third in April—May. The highest population was in May and it differed significantly from all other months excepting August. The minimum population was in June and it differed significantly from all other months This low population may be due to hot weather or owing to less new growth. Thus, the presence of all stages of the webbers at a time throughout the year suggests that these insects had overlapping of generations and are active throughout the year.

Population structure: Table 1 shows that as many as 474.50 larvae + pupae (378.95 larvae + 86.55 pupae) of jujube leaf-webber were observed during 1978-1979 and Table 2 shows that the proportion of the 4 species of jujube leaf-webbers.

The population of *S. univocalis* was higher than all the other species of webbers and thus *S. univocalis* was the dominant species among the jujube webbers.

Acknowledgement:—The authors thank the Director, Commonwealth Institute of Entomology, London for arranging the identification of the specimens and to Dr. G. S. NIJAR, Professor-cum-Head, Department of Horticulture, Punjab Agricultural University, Ludhiana for providing orchard facilities and to Dr. A. S. SIDHU, Professor-cum-Head, Department of Entomology, Punjab Agricultural University, Ludhiana for other facilities and encouragement.

REFERENCE

WADHI, S. R. & H. N. BATRA (1964) Pests of tropical and subtropical fruit trees, 227—261, *in Entomology in India*, Entomological Soc. of India, New Delhi.

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 357 *to* 362

EFFECT OF TIME OF SOWING AND INSECTICIDAL TREATMENTS ON THE PESTS OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.) AND ON SEED YIELD

ASIM K. GHOSH & M. R. GHOSH

Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, India.

(*Received 25 August 1980*)

Indian mustard (*Brassica juncea* L.) sown during October gave better growth of plants and higher yield of seed than those sown during November. Application of insecticides as spray also were significantly superior to untreated plots with respect to seed yield or the crop. Crops sown during October and receiving spray with endosulfan at 0.04% in the first round with the inception of pest incidence followed by methyl demeton at 0.025% after 15 days and repeating the same at the same interval upto the pod filling stage of the crop gave better yield of seed as compared to identical treatment beginning with quinalphos 0.04% and treatment with methyl demeton at 0.025% alone. However, there was no significant difference among the different insecticidal treatments. It has been contended that slight infestation of *Lipaphis erysimi* (Kalt.) has no remarkable effect on seed yield.
(*Key words*: time of sowing, insecticical treatments, mustard pests, seed yield)

INTRODUCTION

Breaking of the synchrony between the vulnerable growth stage of the plants and the time of incidence of pest is one of the cultural methods of pest conrtol. It has been suggested that such asynchrony may be brought about between the key pest of mustard, *Lipaphis erysimi* (KALT.) and mustard crop by advancing the date of sowing of the crop (BHATTACHARJEE, 1961; MAINI, 1965). This is possible when there is only one major pest or the time of occurrence of major pests is more or less identical. It has recently been reported that mustard and rape in West Bengal are ravaged by quite few other pests like *Crocidolomia binotalis* (ZELL) and *Plutella xylostella* (KIRK.) which have different periods of preponderence from aphid (GHOSH, 1979). However, with a view to evaluate the applicability of advanced date of sowing of mustard to avoid damage by aphid and its effect on other pests a field trial was taken up at Kalyani, West Bengal during the crop season of 1977–78.

MATERIALS AND METHODS

A field trial was laid out in split plot design with Indian mustard (*Brassica juncea* L.) variety 'Varuna'. The main plot treatments consisted of three dates of sowing as October 29, 1977, November 15, 1977 and November 29, 1977 and four sub-plot treatments were: (1) Spraying with endosulfan at 0.04% with the inception of aphid incidence followed after 15 days by two rounds of spraying with methyl demeton at 0.025% at the same interval; (2) Spraying with quinalphos at 0.04% with the inception of aphid incidence and spraying after 15 days with methyl demeton at 0.025% and repeating the same once after 15 days; (3) Spraying with methyl demeton at 0.025% with the inception of aphid incidence and repeating the same twice at 15 days interval; (4) No insecticidal treatment. The above sub-plot treatments were started on December 14, 1977 on plots

sown on October 29, 1977 and on plots sown on later two dates it was started on January 4, 1978. Each of the treatments were replicated 4 times. Spraying was done with hand compression sprayer to give full coverage. Seeds were sown in line at 35cm distance and the plants were thinned to maintain plant to plant distance at 25cm within the row. All the treatments recieved uniform cultural practices for raising the crop.

Observations on the incidence of pests were taken from December 15, 1977 and repeated at weekly intervals till the crops matured. Incidence was recorded in each subplot on 5 randomly selected and labelled plants. The record of aphid incidence was done by scoring degree of infestation as given by MUKHOPADHYAY & GHOSH (1979) and for other pests number of larvae on the selected plants were recorded. Height of the selected plants was recorded from middle of January and continued at weekly intervals throughout the season and final post harvest data of plant height, number of branches per plant, number of fruits per plants and seed yield of each sub plot leaving 50 cm along the border were recorded.

RESULTS AND DISCUSSION

Effects on aphid infestation:—Incidence of aphid, *Lipaphis erysimi* (KALT.), as recorded by the observations on untreated plants of all dates of sowing revealed some difference of the starting of incidence. This was during the second week of December on plants sown on 29 October 1977 (first date of sowing) and during the fourth week of December on plants sown on 15 December 1977 (second date of sowing) and 29 November 1977 (third date of sowing). The age of the plants of the three dates of sowing at the time of inception of aphid incidence was 43, 38 and 23 days respectively. In spite of these difference sin the period of inception of incidence the peak of population incidence did not vary remarkably and was recorded during thirdweek of January 1978. The age of the plants of the three dates of sowing at thepeak of incidence of aphid was 87, 72 and 57 days respectively. The incidence of aphid persisted on plants of all dates of sowing till the plants were harvested (Fig. 1).

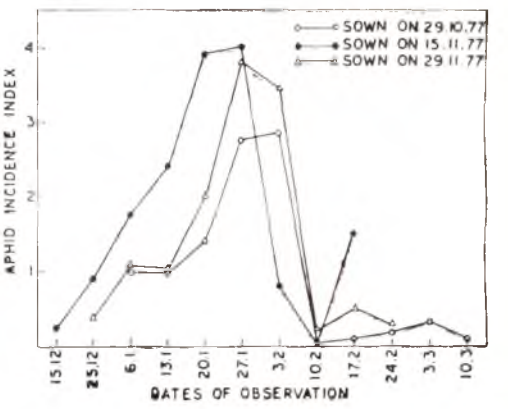


Fig. 1. Aphid incidence pattern on plants of different dates of sowing.

Statistical analysis of the data on aphids during peak period of incidence revealed that both the main plot treatments (dates of sowing) and subplot treatments (spraying with insecticides) differed significantly. The incidence was minimum on plants of last date of sowing during observations of 20 and 27 January 1978 and on first date of sowing during observation of 3 February 1978 and highest mean incidence was recorded on plants of first date of sowing in observation of 20 January 1978 and on plants of second date of sowing in observation of 27 January 1978 and 3 February 1978. The different insecticidal treatments differed significantly from untreated control but there was no statistical difference among the different sets of insecticidal treatments during any of the observations. The interaction between the dates of sowing and insecticidal treatments was significant for observations of 20 January 1978 and 27 January 1978 but it was not so for the observation of 3 February 1978 (Table 1).

Effect on chewing pests:—The larvae of sawfly (*Athalia proxima lugens* (KLUG.),

TABLE 1. Influence of date of sowing and insecticidal treatment on incidence of pests.

Treatments	Mean degree of aphid incidence for plant			Larval population for 5 plants (Mean of all observations)	
	20 Jan '78	27 Jan '78	3 Feb'78	sawfly	Cabbage worm
Date of sowing (main plot treatments)					
October 29, 1977	1.76	2.41	0.78	3.33	10.72
November 15, 1977	1.34	2.63	2.51	2.00	1.32
November 29, 1977	0.91	1.74	2.02	0.42	1.66
SEM ±	0.082	0.0855	0.1418		
CD at 5%	0.2381	0.2463	0.4085		
Insecticides (Subplot treatments)					
Quinalphos/methyl demeton	0.95	1.68	1.48	1.17	4.75
Endosulfan/methyl demeton	1.06	1.87	1.67	0.83	2.07
Only methyl demeton	0.97	1.75	1.32	1.75	4.18
No insecticide	2.35	3.75	2.37	1.58	3.68
SEM ±	0.0954	0.0987	0.1637		
CD at 5%	0.2749	0.2844	0.4718		
Interaction (Date of sowing × Insectide)	Sig.	Sig.	NS		

larger cabbage worm (*Crocidolomia binotalis* CELL.) and larvae of diamond back moth (*Plutella xylostella* KIRK.) was recorded to be of some economic importance than others (GHOSH, 1979). These occurred in somewhat definite succession.

The incidence of sawfly larvae was restricted during January when they infested plants of all age but was more predominant on plants of first date of sowing and it was lowest on plants of last date of sowing. Larger cabbage worm was recorded first during middle of December when it infested only plants of the first date of sowing and the population was remarkably high. This insect persisted till maturity of the crops but the population was comparatively low during the latter month than the same during December. However, the plants of the first date of sowing harboured higher portion of population than on plants of second and third dates of sowing. But when the plants of first date of sowing was harvested the population of cabbage worm on the later two dates of sowing increased (Table 1). The incidence of the larvae of diamond back moth could be noticed only during March which appeared to be late as compared to that observed during other years (GHOSH, 1979). By the time the larvae appeared the plants of the first and second dates of sowing were already harvested and thus evaded the damage due to this pest.

The incidence of these insects was not appreciably high to cause any remarkable injury to the crop and thus affect yield. However, it could be found that by early sowing of the crop not only the damage due to larvae of diamond back moth can

be evaded in certain years, the duration of incidence of other chewing insects like sawfly larvae and larger cabbage worm can be reduced to a large extent. As the population of the mentioned chewing insects was low the data of observations on them were not subjected to statistical analysis but it appears that the insecticidal treatments had no remarkable effect on these insects (Table 1).

Effects on yield attributing characters and seed yield:—The height of plants showed significant difference between the different dates of sowing upto 27 January 1978. But during obervation of the subsequent three weeks the plants of last two dates of sowing did not differ significantly in height though the plants of the first date of sowing was significantly taller than the plants of the later two dates of sowing (Table 2). It therefore, implies that there is a critical period of sowing of this crop, probably the month of October, after which plants ultimately do not grow in much different way specially with respect to height. When the hight of the plants of different dates of sowing but of same age were compared, it was found that the plants of first date of sowing were much taller than the other two dates of sowing and the latter varied very little (Fig. 2). The insecticidal treatments were significantly superior to untreated control but in this attribute also the different insecticidal treatments did not vary significantly among themselves and the interaction between dates of sowing and insecticidal treatments was not significant on all the dates of observations (Table 2).

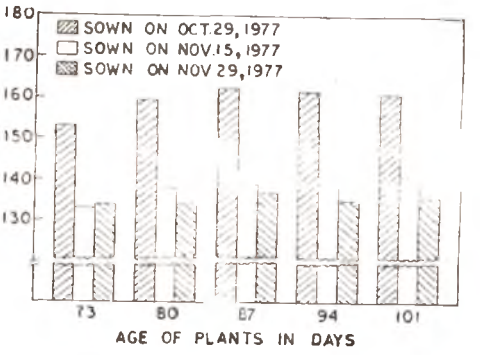


Fig. 2. Effect of date of sowing on plant height.

TABLE 2. Effect of date of sowing and insecticidal treatments on preharvest plant height.

Treatments	Mean height (cm) of plant on			
	27 Jan '78	3 Feb '78	10 Feb '78	17 Feb' 78
Date of sowing (main plot treatment)				
October 29, 1977	162.40	162.31	161.11	161.84
November 15, 1977	133.19	137.60	139.35	139.03
November 29, 1977	108.74	128.11	133.62	134.03
SEM ±	3.2185	3.3662	3.1258	3.4179
CD at 5%	9.2715	9.6971	9.0045	9.8461
Insecticides (Subplot treatment)				
Quinalphos/methyl demeton	138.08	148.34	150.74	150.58
Endosulfan/methyl demeton	139.49	147.53	140.85	151.72
Only methyl demeton	132.99	143.58	147.26	146.73
No insecticide	128.99	131.25	131.55	133.28
SEM ±	—	3.8870	3.6093	3.9467
CD at 5%	NS	11.1973	10.3975	11.3693
Interaction (Date & Insecticide)	NS	NS	NS	NS

TABLE 3. Effect of sowing and insecticidal treatment on yield attributing characters and seed yield.

Treatments	Final height (cm) of plant	Number of branches per plant	Number of fruits per plant	Seed yield (Kg) per plot (3m×1.5m)
Dates of sowing (Main plot treatment)				
October 29, 1977	159.77	40.22	302.49	7.69
Vovember 15, 1977	137.50	18.30	106.10	3.46
November 29, 1977	135.46	12.14	107.62	3.37
SEM ±	3.3600	2.5068	23.46	0.6974
CD at 5%	9.6794	7.2214	67.6031	2.0090
Insecticides (Subplot treatments)				
Quinalphos/methyl demeton	150.58	22.66	198.17	6.02
Endosulfan/methyl demeton	151.11	23.80	213.05	6.81
Only methyl demeton	142.44	26.38	193.55	4.70
No insecticide	132.95	21.36	83.55	1.83
SEM ±	3.8799		27.09	0.8052
CD as 5%	11.1768	NS	78.0613	2.3197
Interaction (Date & Insecticide)	NS		NS	Sig.

The other yield attributing characters like final height of the plants, number of branches and number of fruits per plant and also the seed yield varied significantly with respect to time of sowing. It was found that on these characters the first date of sowing was significantly superior to other two dates of sowing. The last two dates of sowing were not significantly different between themselves. Insecticidal treatments also differed significantly from untreated control excepting the number of branches per plant. Further in final height of the plant only methyl demeton application was not statistically different from untreated control while the other two treatments though not mutually different were significantly superior to no treatment of insecticide or with treatment of methyl demeton alone.

Number of fruits per plant in the insecticide treated plots was significantly superior to untreated control but the different insecticidal treatment did not vary statistically among themselves. With respect to seed yield also the insecticidal treatments differed significantly from untreated plots and interestingly the plots receiving only methyl demeton spray yielded seeds that were significantly less than other two insecticide treatments. Interaction between the date of sowing and insecticidal treatments was significant with respect to seed yield but was not significant with respect to yield attributing characters considered here (Table 3).

Analyses of data as elaborated in the foregoing revealed that earlier sowing (October) was better for obtaining favourable growth and other yield attributing characters leading to better realisation of seed yield than sowing at later dates (i.e. November). The significant interaction between dates of sowing and insecticidal treatments

during peak period of incidence of aphid (Table 1) indicated that further enhancement of yield was possible by resorting to aphid control measures on the early sown crops. It was found that the aphid infestation was in general lower in the plots receiving first application of spray with quinalphos at 0.04% followed after 15 days by spraying with methyl demeton at 0.025% twice at the same interval (Table 1) but with regard to yield attributting characters like height of plant at harvest and number of fruits per plant and also seed yield the insecticidal treatments of endosulfan at 0.04% during first round followed by methyl demeton at 0.025% at 15 days interval was better than other treatments (Table 3). It might be noted that the mean population of chewing pests was comparatively low in the plots receiving the aforesaid treatment and this might have some role in the ultimate effects. It has been reported that early sown crop harboured lesser infestation of aphid which sometimes evaded the infestation (BHATTACHARJEE, 1961; MAINI, 1965) but during the present investigation the infestation was not completely evaded and during peak of incidence of aphid the early sown crop harboured higher degree of incidence than the later two dates of sowing. However, the duration of heavy population incidence was lesser on the plants sown during October than that in November and plants remained aphid free for a longer period during the initial phase of growth of the plant in the first date of sowing.

REFERENCES

BHATTACHARJEE, N. S. (1961) Control of mustard aphid by cultural practices. *Indian Oilseeds J.*, 5,. 133—138.

GHOSH, M. R. (1979) Comparative efficacy of some systemic insecticides to control mustard aphid, *Lipaphis erysimi* (KALT.) and notes on some related problems. *Pesticides*, **13**, 13—17.

MAINI, N. S. (1965) A review of the research work done at Regional Research Centre Oilseeds (PIRRCOM), Patiala. *Indian Oilseeds J.*, 9, 138—145.

MUKHERJEE, D. & M. R. GHOSH (1979) Effect of phased application formothion and methyl demeton on the incidence of *Lipaphis erysimi* (KALT.) and yield of rapeseed. *Indian J. agric. Sci.*, **49**, 898—900.

Entomon, 1981, *Vol.* 6, *No.* 4, *pp.* 363 *to* 366

STUDIES ON THE APHIDS (HOMOPTERA : APHIDIDAE) FROM EASTERN INDIA

MANDIRA CHATTERJEE, P. K. MANDAL & D. N. RAYCHAUDHURI

Entomology Laboratory, Department of Zoology, University of Calcutta, Calcutta—19, India

(Received 20 September 1980)

Two new species, viz., *Eutrichosiphum (Eutrichosiphum) manoji* from Sikkim and *Greenidea (Trichosiphum) brachyunguis* from Sikkim and a new alate morph of *Eutrichosiphum (Eutrichosiphum) arunachali* Basu, Ghosh and Raychaudhuri from Arunachal Pradesh (NEFA) are described.

(Key words: two new greenideine aphids from eastern India)

While working on a collection of aphids made during the period 1968—1973 two new species and one undescribed morph could be found and these are described here.

Materials of the new species are in the collection of the Entomology Laboratory, Department of Zoology, University of Calcutta.

1. Eutrichosiphum (Eutrichosiphum) manoji sp. nov.

Apterous viviparous female (Fig. 1) :

Body elongated oval, about 2.47—2.56 mm long with about 1.02—1.11 mm as maximum width. Head pale brown, smooth and bearing many long hairs with acuminate to furcated apices. Antennae 5-segmented, about 0.51 × body, concolorous with head excepting apical portion of segments IV and V; flagellum gradually distinctly imbricated apicad; precessus terminalis 1.45 × base of segment V and about 0.43 × segment III; hairs on flagellum sparse with acuminate to acute apices; longest hair on antennal segment III about 3.30 × basal diameter of the segment. Rosrtum reaching abdominal segment 2: segments 4 + 5 of rostrum slender and acute, about 3.57 × second segment of hind tarsus and segment 4 about 7.33 × segment 5, with about 12—14 secondary hairs. Abdominal dorsum pale and smooth, long and short hairs occur intermingled, longer ones with furcated apices. and shorter ones with acute to acuminate apices; longest hair on anterior abdominal tergites about 3.10 × basal diameter of antennal segment III: each of tergites 7 and 8 with 2 hairs and these are about 3.40 × and 3.70 × the mentioned diameter respectively. Siphunculi pale with apicalmost portion brown, slightly curved outwards, about 0.43 × body and about 6.90 × its maximum width; width of siphunculi at base 2.87 ×, at middle 5.62 × and at apex 1.75 × middle diameter of hind tibiae; hairs on siphunculi mostly fine and some with acuminate apices; entirely spinulose and spinules being dense towards apex. Cauda semioval with 7 hairs. Legs concolorous with head but spinulose striae present on venter of femora; first tarsal segments bear 7, 7, 7 hairs.

Measurements of the holotype in mm

Length of body 2.56, width 1.11; antenna 1.35, segments III : IV : V 0.57 : 0.22 : (0.16

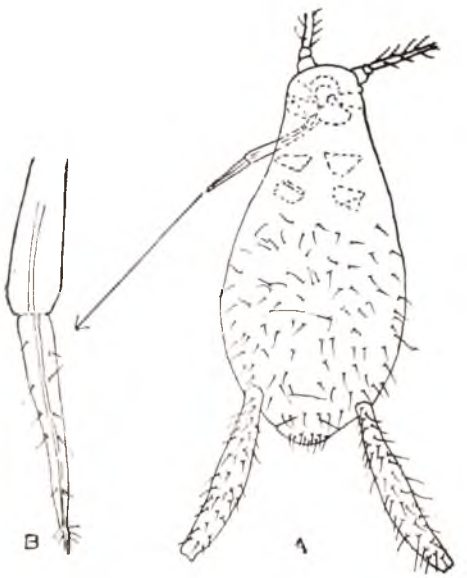


Fig. 1. *Eutrichosiphum* (*Eutrichosiphum*) *manoji*, sp. nov., Apterous viviparous female: A. body; B. u.r.s.

to 0.25); ultimate rostral segment (4+5) 0.38; second joint of hind tarsus 0.10; siphunculus 1.20.

Holotype: Apterous viviparous ♀, INDIA : SIKKIM, Gangtok *c*1675m, 28.x.1971 from *Quercus* sp. (Fagaceae), coll. M. R. Ghosh, **Paratypes:** two apterous viviparous ♀♀. collection data same as for the holotype.

Remarks: Among the known species of the subgenus *Eutrichosiphum*, under the genus *Eutrichosiphum*, the new species approaches *taoi* Ghosh, Basu and Raychaudhuri (1970) by having completely smooth abdominal dorsum, but differs in the following characters ; ratio of segments 4+5 of rostrum : h. t. 2, ratio of segment 4: segment 5 of rostrum and number of secondary hairs on rostrum beside other characters.

The new species is named after the collector Dr. Manoj Ranjan Ghosh.

2. Greenidea (Trichosiphum) brachyunguis, sp. nov.

Apterous viviparous female :

Body about 2.51—3.0 mm long and about 1.44—1.88 mm as maximum width. Head brown, smooth, bearing hairs with fine to acuminate apices. Antenna 6-segmented, concolorous with head excepting segments III and IV which are somewhat paler, about, 0.68—0.75 × body, flagellum gradually more distinctly imbricated apicad; processus terminalis about 1.73—1.92 × base of segment VI and about 0.48—0.60 × segment III; longer hairs on flagellum with fine apices but shorter ones with acuminate apices, longest hair on segment III about 3.76—4.53 × and shortest one about 1.0—2.33 × basal diameter of the segment. Rostrum reaching midcoxae; segments 4+5 about 1.29—1.53 × second joint of hind tarsus and segment 4 about 3.44—4.20 × segment 5 and bears 11—12 fine secondary hairs. Tergum sclerotized, dark brown, smooth bearing many long hairs with fine apices and a few with acuminate apices, 7th tergite with 7 hairs and 8th tergite with 2 long fine hairs; longest one on anterior abdominal tergites about 3.11—3.66 ×, on tergite 7 about 2.47—3.33 × and on tergite 8 about 2.94—3.46 × basal diameter of antennal segment III respectively; abdominal venter with a dark spinopleural sclerotic patch and with evenly and densely distributed spinules keeping the marginal area free, spinules stout and long. Siphunculi dark brown with pale apex, curved outwards, basally prominently reticulated, about 0.29—0.32 × body and about 3.74—6.50 × its maximum width, at base about 2.11—2.66 ×, at middle about 3.61—4.46 × and at apex about 1.50—1.93 × width of middle of hind tibiae; hairs on siphunculi numerous and flagellate, longest hair being about 1.70—2.02 × basal diameter of the siphunculus; spinules present

in distinct transverse rows, these having denser apically. Cauda with a distinct median process. Legs concolorous with the head; femora with spinules arranged in rows dorsally; tibiae smooth without any imbrication, F. T. C. 7, 7, 7.

Measurements of the holotype in mm: Length of body 2.56, width 1.51; antenna 1.94, segments III:IV:V:VI 0.69:0.22:0.24: (0.20+0.36); ultimate rostral segment (4+5) 0.24; second joint of hind tarsus 0.16; siphunculus 0.94.

Holotype: Apterous viviparous ♀, INDIA : SIKKIM, Gangtok, 27.xi.1971 from *Quercus* sp. (Fragaceae), coll. M. R. Ghosh, **paratypes:** 6 apterous viviparous ♀♀ and 9 nymphs with the collection data same as for the holotype.

Remarks: The new species under the subgenus *Trichosiphum* comes close to *kuwaniae* (Pergande), *sinensis* Raychaudhuri (1956); *prunicola* Ghosh, Banerjee and Raychaudhuri (1971) and *carpini* Takahashi (1963) in having evenly distributed spinules on venter of abdomen. But the species can easily be separated from those by the presence of long fine hairs on abdominal dorsum and on flagellum, by smooth tibiae and nearly smooth antenaal segment III. Beside these, the new species differs from *kuwaniae* (Pergande), *prunicola* Ghosh, Banerjee and Raychaudhuri and *carpini* Takahashi by having shorter processus terminalis in comparison to the base of segment VI.

3. Eutrichosiphum (Eutrichosiphum) arunachali Basu, Ghosh, ahd Raychaudhuri *Eutrichosiphum (Eutrichosiphum) arunachali* Basu, R. C., Ghosh, A. K. and Raychaudhuri, D. N. 1972. Sci. Cult., 38: 494-495.

Alate viviparous female:

Body elongated about 1.86 mm long and about 0.87 mm as maximum width. Antennae 5-segmented about 1.40 mm long and about 0.75 × the length of body, slightly darker than head, segment III with 29—30 transversely oval secondary rhinaria arranged throughout the length of the segment; processus terminalis about 1.73 × base of last antennal segment and about 0.30 × segment III; hairs on flagellum long, with acute apices and the longest one about 5.33× basal diameter of segment III. Rostrum reaches hind coxae; ultimate rostral segment (4+5) acute and about 1.91 × second joint of hind tarsus and segment 4 about 4.57 × segment 5. Abdominal dorsum sclerotized with uniformly distributed minute spinules, dorsal abdominal hairs, both longer and shorter ones; with accuminate to acute apices; longest hair on anterior abdominal tergite about 3.33 × and the shortest one about 0.66 × the basal diameter of antennal segment III; tergite 7 with 3 and 8 with 2 fiine hairs respectively and the longest one on tergite 7 about 3.0× and on 8 about 4.0× the basal diameter of antennal segment III. Siphunculi dark brown, with faint reticulation on the middle portion and with transverse rows of spinules from the very base to apex which are dense towards the apicalmost portion, slightly curved outwards, about 0.45 × the length of body and about 8.50 × its maximnm width: width at base about 4.0×, at middle about 3.66 × and at apex about 1.66 × the middle diameter of hind tibiae; hairs on siphunculi long and fine, longest one about 1.91× the basal diameter of the siphunculi. Cauda semioval with 8 hairs. Legs concolorous with head; hairs on legs with acute apices; tibiae almost smooth excepting the apical portion, F. T. C. 7, 7, 7. Wing venation normal. Other characters as in apterous viviparous female.

Measurements of the specimen in mm: Length of body 1.86, width of the body

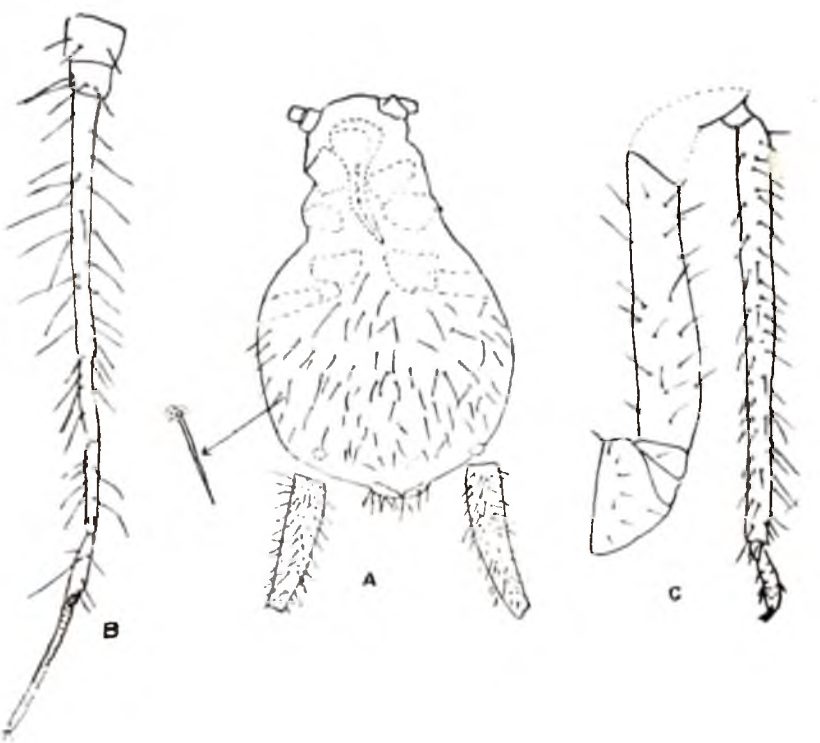


Fig. 2. *Grneenidea* (*Trichosiphnm*) *brachyumguis*, sp. nov. Apterous viviparous female: A. body; B. antenna; C. hind leg.

0.87; antenna 1.40, length of antennal segments III:IV:V 0.37 :0.19: (0.13+0.22); ultimate rostral segment 0.19; second joint of hind tarsus 0.09; siphunculus 0.84.

Collection data: Three apterous viviparous ♀♀ and one alate viviparous ♀ from *Quercus* sp. (Fagaceae), Paksing, ARUNACHAL PRADESH, 20. ii. 1971, coll. R. C. Basu.

Remark: Basu *et al.* (1972) described the species from apterous viviparous females collected in ARUNACAAL PRADESH (NEFA). While re-examining those materials, hitherto unknown alate morph of *arunachali* has been found and it is being described here.

Acknowledgements:—Thc authors are thankful to the Head of the Department of Zoology for Laboratory facilities and to the U. S. Department of Agriculture for partly financing a PL 480 project during 1968—1973.

REFERENCES

GHOSH, A. K., R. C. BASU & D. N. RAYCHAUDHURI (1970) Studies on aphids (Homoptera : Aphididae) from eastern India. New species and new records from Assam. *Oriental Ins.*, **4** (1). 68—69.

RAYCHAUDHURI, D. N. (1956) Revision of Greenidea and related genera (Homoptera : Aphidae). *Zool. Verhandl.*, **31**, 56—58.

GHOSH, A. K., H. BANERJEE & D. N. RAYCHAUDHURI (1971) Studies on the aphids (Homoptera : Aphidiae) from eastern India. *Proc. Zool. Soc., Calcutta*, **24**, 104—105.

TAKAHASHI, R. (1963) Two new genera and five new or little known species of Aphididae from Japan. *Kontyu*, **31** (3) 159.

BASU, R. C., A. K. GHOSH & D. N. RAYCHAUDHURI (1972) A new species of *Lutrichosiphum* and notes on other new records of aphids (Insecta : Homoptera) from NEFA (Arunachal). *Sci. Cult.*, **38**, 494—495.

INFORMATION TO CONTRIBUTORS

General: ENTOMON will accept original articles arising from studies on insects and other land arthropods. However, papers purely of morphological, histological or anatomical nature based on light microscopy will not be considered. Material submitted for publication in the journal should not have been published or submitted for publication elsewhere. Copyright of the articles published in *Entomon* will remain exclusively with the ·AE. Manuscripts in duplicate, including figures must be sent by Registered Mail to the *Managing Editor, ENTOMON, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695 581.*

Articles should be in English only and may be either *Brief Communications* not exceeding two printed pages, or *Papers*, normally not exceeding ten printed pages. Reports not exceeding a column will also be accepted for publication. The authors should cunsult a recent issue of the journal and follow the style closely.

Text: Papers may, as far as possible, be organised as under: Abstract, Introduction, Material and Methods, Results and Discussion, Acknowledgements, References, Legend, Table and Foot-notes. All pages should be numbered serially. Brief Communications need not have the above format.

Articles should be neatly type written double spaced, including References, Legend, Tables etc., on one side only of good quality bond paper, leaving sufficient margin.

Foot-notes should be avoided as far as possible. When included they should be given on a separate sheet. In the text, reference to foot notes shuld be indicated by superscript numerals.

Tables should be numbered in Arabic numerals, and should be given on sheets separate from the text. The approximate position of tables in the text should be indicated in the left magin and circled.

Illustrations should accompany the script separately. The short title of the article and figure number should be indicated on the reverse side of the illustrations. Legend should be typed on sheets separate from the text. Line drawings and photographs should be consecutively numbered together in Arabic numerals without distinction between drawings and photographs. Photographs should be organised and mounted in the form of plates. The approximate position of the illustrations in the text should be indicated in the left margin and circled. Blocks up to an equivalent of one full page size are allowed free of cost. However additional blocks will be fully charged for. Authors are advised to carefully plan their illustrations so as to occupy minimum space and permit sufficient reduction. This is in the interest of the authors as well as the journal.

Use only **metric units** as far as possible. Abbreviations of units should not be followed by full stop unless to avoid confusion.

References should be cited in the text by name(s) of author(s) and year of publication as: NAYAR (1958), or NAYAR (1958). NAYAR *et al.* (1970) etc. Abbreviate title of periodicals according to *World List of Scientific Periodicals*, 4th ed., Butterworth, London (1963). The following style should be used for listing references:

Articles in journals: NAYAR, K. K. (1958). Studies on the neurosecretory system of *Iphita*. V. Endocrine basis of oviposition in female. *Proc. Indian Acad Sci.*, **47B:** 233-251.

NAYAR, K. K., M. BALLS & E. ARTHUR (1970) Transmission of amphibian lymphosarcoma to and through insects. *Oncology*, **24B:** 370—377.

Books: NAYAR, K. K. (1973) *Elements in Insect Endocrinology*, Prentice Hall, India, 56pp. *Chapter in a book compiled, and edited*: GILBERT, L. I. & D. S. KING (1973) Physiology of growth and development: Endocrine aspects, 149—370, *in*: *The Physiology of Insecta*, Vol. **1,** 3rd ed. (ed. ROCKSTEIN, M.), Academic Press, New York & London.

Reprints: No gratis reprints will be supplied. The number of reprints required should be specified as soon as the paper is accepted for publication in the journal. Table showing the cost of reprints will be supplied to authors when acceptance of the paper is communicated.

Editors reserve the right to revise the wording of manuscripts accepted for publication. The authors are solely responsible for the views expressed in their articles.

Reg. No. R. N. 29386 / 76

ENTOMON is covered in the following abstracting / indexing journals: *Chemical Abstracts* (Chemical Abstracts Service, The Ohio State University, Columbus, Ohio 43210, U. S. A), *Review of Applied Entomology* (Commonwealth Institute of Entomology, 56 Queen's Gate, London SW7 5JR, England), *Current Contents / Agriculture, Biology & Environmental Sciences* (Institute of Scientific Information, 3501 Market Street, Philadelphia, Pa. 19104, U. S. A.), *Biological Abstracts* (Biosciences Information Service, 2100 Arch Street, Philadelphia, Pa. 19103. U. S. A), *Entomology Abstracts* and other relevant *Abstracts* (Information Retrieval Limited, 1 Falconberg Court, London WIV 5FG, England), *Referativnyi Zhurnal* (The Institute of Scientific Information, Academy of Science of the U. S. S. R., Baltijskaya ul, 14, Moscow A—219, U. S. S. R.).

Printed by V. K. K. Prabhu at GEO Printers, Plamood, Trivandrum 695 004
for the Association for Advancement of Entomology.